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Action Current Study of Contraction-Movement Relationships in Golf Stroke

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(Submitted for publication March, 1948)

INTRODUCTION

THE discrepancies between experimental analysis and the traditional analysis of contraction-movement relationships constitute some of the major problems that confront the student of kinesiology. These analyses often leave the student with what appears to be two sets of contradictory material or factual truths. For any given individual at any given instance there can be, however, only one set of factual truths regarding contraction-movement relationships. These truths can be based only upon the empirical facts of observation and experimentation, and it is suggested that neither the methodology nor the basic data of traditional kinesiological analysis is sufficient to establish a factual truth.

An examination of traditional kinesiological procedures will reveal that logically these analyses can be accounted no more than theoretical reconstructions. The basic data of the analyses are the formulations of contraction-movement relationships as presented by anatomists. These relationships, based on the points of muscular attachment and lines of pull, become the units or building blocks with which complex human skills are reconstructed. By observation of a similarity between some phase or aspect of a skilled movement and one of these units, the contraction-movement relationships are deduced. In short, the methodology of the traditional kinesiology can be said to be a form of analogical deduction.[2] There can be, of course, no objections to deductive procedures as such; deductions have an important role in scientific progress. However, until a deduction is tested by ample evidence from observation or experiment it must logically remain a hypothesis, a speculation.

The traditional analyses simply constitute the first step in a scientific program. These analyses, based upon an intimate knowledge of anatomy and mechanics, present the logical possibilities of contraction-movement relationships. It is to be emphasized that these

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[1]The experimental work covered in this paper was completed in the Department of Physical Education, State University of Iowa. R. H. Stetson of the department of psychology of Oberlin College, provided most of the apparatus and rendered much valuable assistance.

[2]This is especially true in the high-speed skills of throwing, striking, kicking, running, jumping, etc. The very nature of these skills just about precludes the possibility of determining muscle action by palpation.

analyses simply state what relationships *may* obtain. The actual relationships can be determined only by observation and experiment.

The discrepancies between experimental analysis and traditional analysis indicate that the basic data of the latter do not constitute an adequate notation for deriving precise contraction-movement relationships. It also indicates an urgent need for experimental verification of the latter analyses. This study, in part, represents an experimental determination of the extent to which the coordinations of a group of better than average golfers conform to the formulations of the traditional analysis.

A second purpose of this study was to obtain data relative to the driving contractions of the golf stroke. The experimental evidence has indicated that skillful performance of rapid reciprocal movements involving the fingers, hand, arm, leg, and trunk exhibit a momentum phase and are thus ballistic in nature (1, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 15, 16, 17, 18, 19, 20, 21, 22). There is, however, little experimental evidence on the nature of contraction-movement relationships of high-speed skills that can be said to culminate in a single blow, e.g., the baseball throw, golf stroke, tennis drive, etc. The traditional kinesiological analyses of these activities generally assume that the driving contractions occur throughout the entire movement excursion. At least one experimental study, on the other hand, suggests the high-speed stroke or blow is essentially ballistic. Stetson and Bouman (18), for example, found that in the rapid performance of a single tapping stroke the driving contractions were ballistic. This study is a further investigation into the contraction-movement relationships of skills involving the delivery of a single blow.

EXPERIMENTAL METHOD

The action-current technique was used to provide a direct physiological measurement of muscle contraction. Simultaneous recording of action currents and movement excursions, as described below, made it possible to study contraction incidence in relation to movement excursion. The muscles investigated were the lateral head triceps brachii, and long head triceps brachii; short head biceps brachii, and long head biceps brachii; anterior deltoid, medial deltoid, and posterior deltoid; latissimus dorsi; and the pectoralis major on both left and right sides.

Four male subjects were used in the experiment, two of whom were members of the University of Iowa physical education department, and two of whom were graduate students in physical education. All subjects had had several years' playing experience and could be considered "good" performers. No subject was experienced in the laboratory procedures of this general type.

The records obtained gave a movement tracing of the golf stroke, the instant of ball contact, and the incidence of muscular

contraction. In reading the records, the beginning of the back stroke was taken as the zero reference point. All measurements were made as occurring forward in time from this reference point.

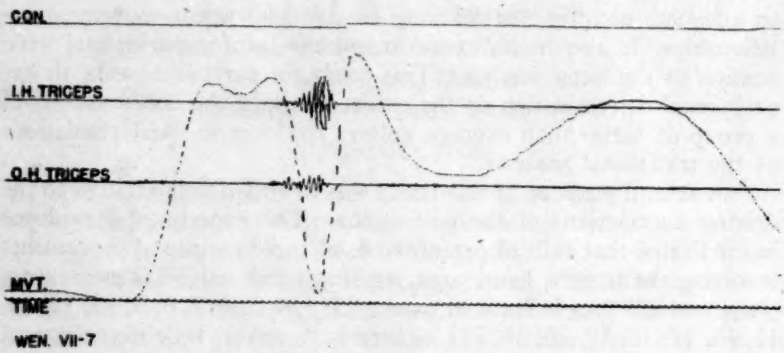

FIG. 1. Representative Record of Golf Stroke. Con.—Contact of golf club with ball. I.H. Triceps—Action currents from long head of right triceps. O.H. Triceps—Action currents from lateral head of right triceps brachii. While lateral head shows increased tension during the entire movement complex, the contraction envelope is clear. Such tension changes often occurred for as long as a minute after completion of the stroke. To call these tension changes part of the contraction would necessitate having a contraction long after the completion of a stroke and while the arm was at rest. Mvt.—Tracing of movement of golf club head. Upward movement of tracing indicates upward movement of golf club. In this record the movement line was attached to the golf club head. Vibration of club shaft during the drive and follow through so distorted the record that it was necessary to keep attachment at upper end of club. Time—Time in .02 sec.

Apparatus.—Polygraph records of the general type shown in Figure 1 were used throughout the study. Recording was done on a Teledeltos Polygraph which has been described by Snodgrass (13).

The path of the movement was recorded by means of a light glass thread-and-rubber band system (1, 16). One end of the thread was attached to the club shaft just below the grip, and the other end was attached to a rubber band. This maintained a light tension on the system and allowed a marker on the thread to follow the movement. Glass beads kept the axis of the movement-recording system parallel with the axis of the polygraph. The recording was mechanically reduced by inserting a length of rubber band between the subject and the marker. Calibration of the system showed a lag of approximately .02 seconds.

Action currents from muscles were recorded on the same record. Detailed descriptions of action current recording techniques and apparatus may be found elsewhere (2, 6, 7, 14, 18).

A photo-electric system was used to record the contact of golf

club with ball during the stroke. Before each stroke the ball was placed upon a small mound of clay so that it interrupted a light beam. A 1.5 cm. displacement of the ball activated the photo-electric system

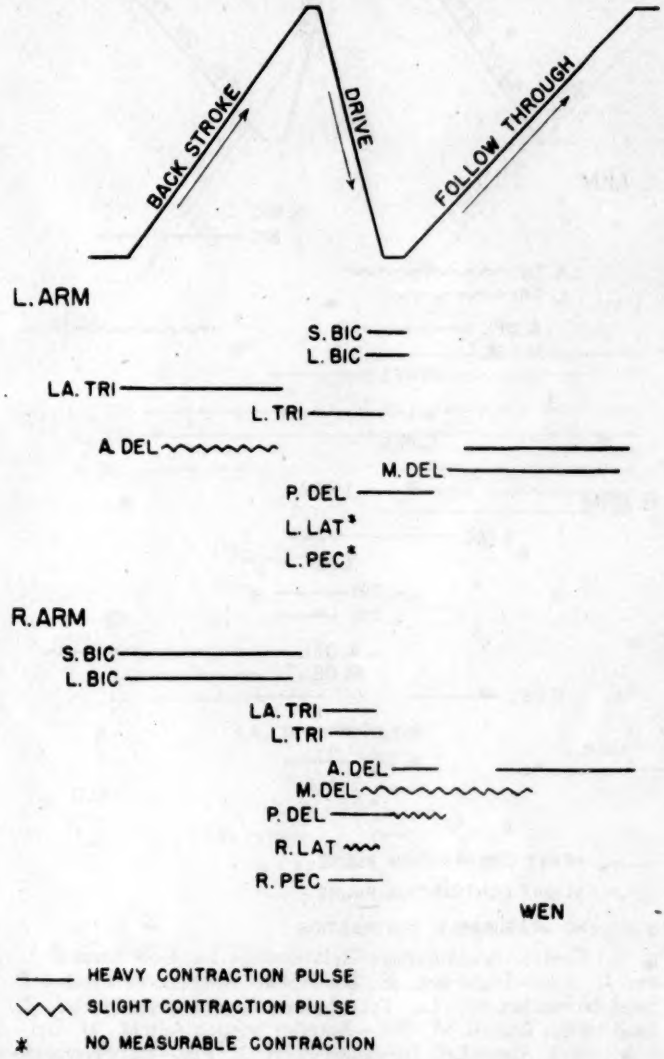

FIG. 2. Contraction-Movement Relationships for Golf Stroke. L. Arm—Left arm. R. Arm—Right arm. S. Bic.—Short head biceps brachii. L. Bic.—Long head biceps brachii. La. Tri.—Lateral head trieeps brachii. L. Tri.—Long head triceps brachii. A. Del.—Anterior portion deltoid. M. Del.—Medial portion deltoid. L. Lat.—Left latissimus dorsi. L. Pec.—Left pectoralis major. R. Lat.—Right latissimus dorsi. R. Pec.—Right pectoralis major.

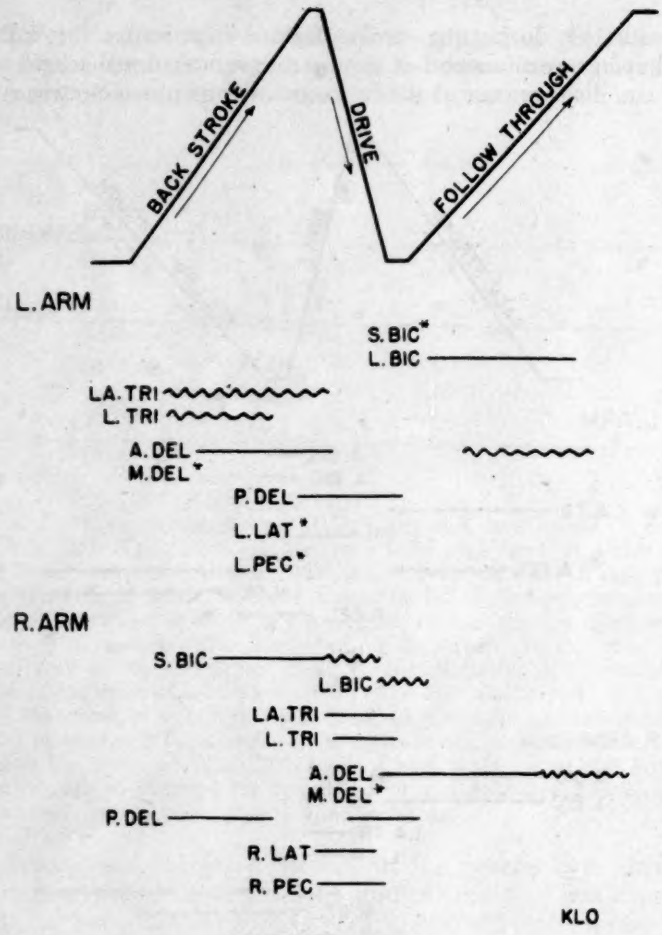

FIG. 3. Contraction-Movement Relationships for Golf Stroke. L. Arm—Left arm. R. Arm—Right arm. S. Bic.—Short head biceps brachii. L. Bic.—Long head biceps brachii. La. Tri.—Lateral head triceps brachii. L. Tri.—Long head triceps brachii. A. Del.—Anterior portion deltoid. M. Del.—Medial portion deltoid. L. Lat.—Left latissimus dorsi. L. Pec.—Left pectoralis major. R. Lat.—Right latissimus dorsi. R. Pec.—Right pectoralis major.

which operated a mechanical relay.[3] Calibration of the relay showed

[3]This procedure made for a slight lag in recording the instant of ball contact; however, an error of 1.5 cm. in a movement arc with a radius of over six feet was well within the limits of accuracy for reading the records. Strictly speaking, the contact recording line of the golf stroke records represents the instant at which the club had carried the ball 1.5 cm.

a lag of .045 seconds. The limitations of the laboratory made it necessary to substitute a small fleece wool ball for the regulation golf ball. To check the possible effects of a lighter ball upon muscle

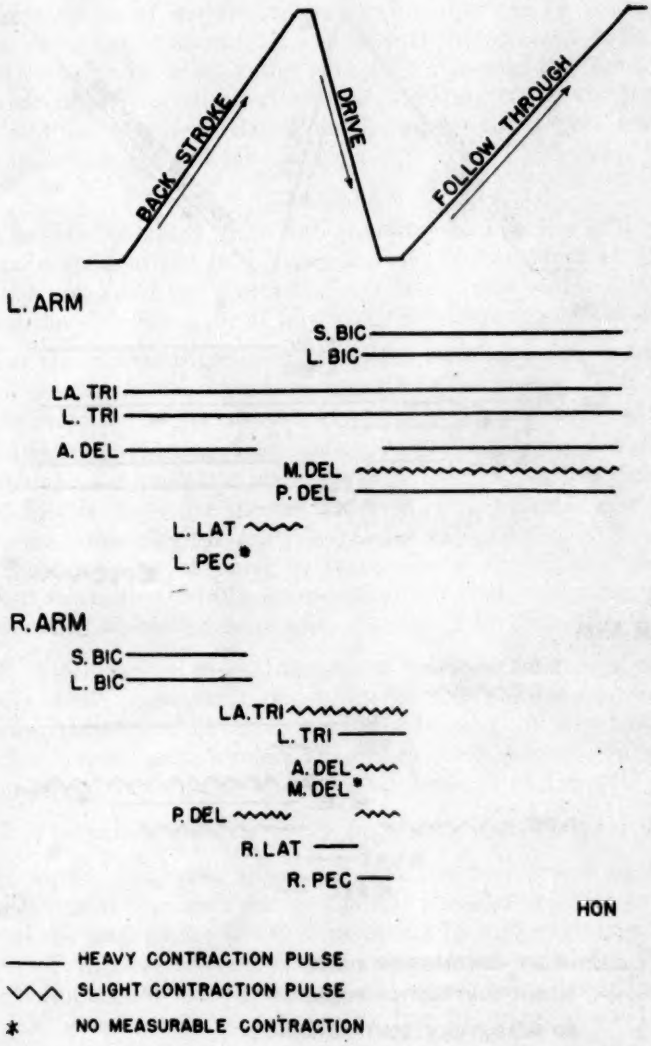

FIG. 4. Contraction-Movement Relationships for Golf Stroke. L. Arm.—Left arm. R. Arm—Right arm. S. Bic.—Short head biceps brachii. L. Bic.—Long head biceps brachii. La. Tri.—Lateral head triceps brachii. L. Tri.—Long head triceps brachii. A. Del.—Anterior portion deltoid. M. Del.—Medial portion deltoid. L. Lat.—Left latissimus dorsi. L. Pec.—Left pectoralis major. R. Lat.—Right latissimus dorsi. R. Pec.—Right pectoralis major.

contraction patterns, a preliminary investigation was made using a soft clay ball weighing as much as a golf ball. No measurable difference was found.

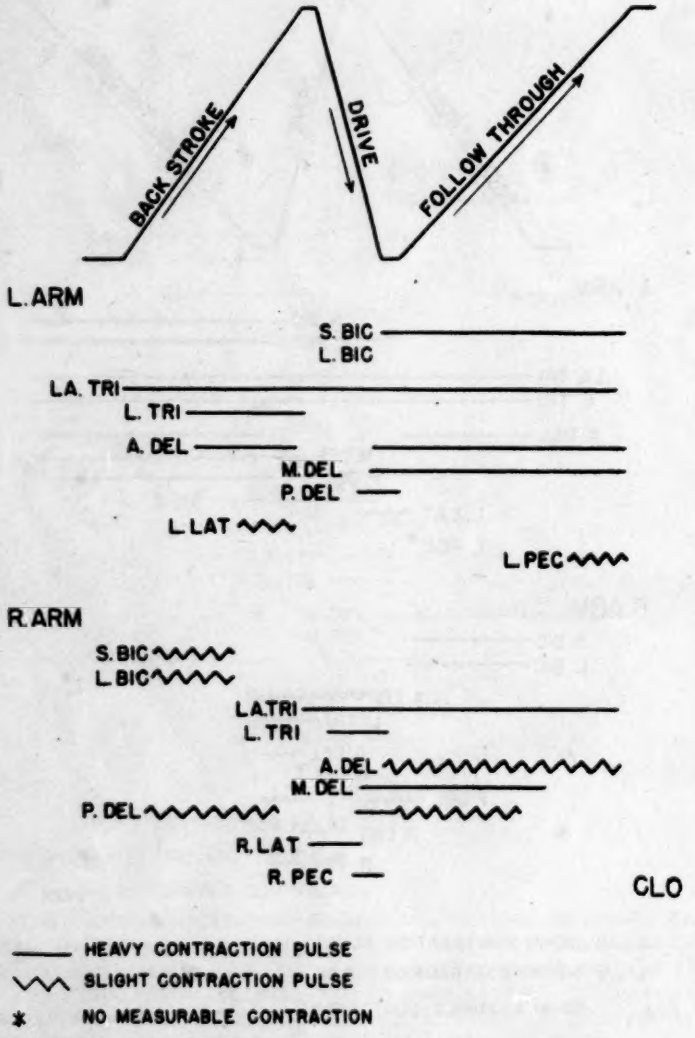

FIG. 5. Contraction-Movement Relationships for Golf Stroke. L. Arm—Left arm. R. Arm—Right arm. S. Bic.—Short head biceps brachii. L. Bic.—Long head biceps brachii. La. Tri.—Lateral head triceps brachii. L. Tri.—Long head triceps brachii. A. Del.—Anterior portion deltoid. M. Del.—Medial portion deltoid. L. Lat.—Left latissimus dorsi. L. Pec.—Left pectoralis major. R. Lat.—Right latissimus dorsi. R .Pec.—Right pectoralis major.

Two section current lines were used in the experiment. In adjusting the amplification, no attempt was made to balance the recording lines; variations at the electrodes render such efforts meaningless. While it is to be emphasized that generally no direct quantitative comparisons of muscle contraction intensity can be made from one recording line to another, it was possible, however, to make some comparisons during a recording period by changing the input plugs to the pre-amplifiers. In most instances, the quantitative comparisons made in this study are relative and based on differences within a single recording line and for a single run.[4]

RESULTS

The data obtained from the subjects used in the golf stroke have been summarized in Figures 2, 3, 4, 5. Six hundred records were measured and the contraction-movement relationship presented represent modal values for at least five recordings from each muscle.

For the individual subject, there was little variation in contraction-movement relationships from one stroke to another. This would seem to indicate that the strokes were well developed habit patterns.[5]

Differences Between Experimental and Traditional Kinesiological Analysis.—Among the most obvious features of the data presented in this study are the many points of disagreement with the traditional kinesiological analysis of the golf stroke. Since these differences may be obtained by inspection of the above figures, a detailed description hardly seems justified. The following points, however, are worthy of emphasis:

1. A comparison of contraction-movement relationships between subjects shows wide variations in timing and general coordination. For most muscles under investigation, the variations were extensive enough to preclude the formulation of any one statement which could be considered an accurate kinesiological analysis of the golf stroke.

2. The partite muscles do not necessarily function as a unit.[6]

3. In the traditional analysis it often has been stated, or at least implied, that the musculature of the left shoulder initiates and does most of the work in the drive. This cannot be said to be true for the subjects of this experiment. The experimental data indicate that the drive is initiated in the right arm. Nor can it be said that the right arm functioned merely as a guide during the drive; powerful con-

[4]The relationships between the mechanical aspects of muscle activity and the electrical output has been shown to be substantially linear for striated muscles (18, 19).

[5]Records taken on several subjects with little or no experience in this stroke showed extensive variation from stroke to stroke. The general tendency was to have contractions appear throughout the entire stroke, with the heavy pulses varying from stroke to stroke.

[6]The differential action of similar muscles has been recently discussed by McCloy (11).

tractions of the right pectoralis major and latissimus dorsi propelled the arm during the downward swing. In most subjects the posterior fibers of the left deltoid did not begin contracting until after the arm was well beyond the latter half of the drive. Contraction in other parts of the deltoid did not occur until shortly before ball contact. No subject showed contractions of the left latissimus dorsi during the drive.

Nature of Driving Contractions.—In previous contraction-movement studies that utilized the techniques followed in this study, the movements involved were relatively simple and were generally confined to a single plane. Under these conditions the movement recording was taken in the plane of the movement and gave a reasonably accurate picture of duration and velocity changes during an excursion. The method of recording action currents simultaneously with a tracing of the movement made it possible to correlate muscle action with the velocity changes of a movement.

The conditions of this investigation are somewhat different. The golf stroke, for example, is an exceedingly complex excursion which generally takes place in three planes. The movement recording system used in this investigation recorded mainly vertical motion, and the tracing obtained was actually a projection of the stroke. While a projection recording may preclude the possibility of correlating the incidence of muscular contraction with the velocity changes of a limb, it was felt that this procedure did not completely vitiate any analysis. The tracings do record the beginning of the stroke and the instant of ball contact. With these reference points it is possible to make a tentative determination of the probable driving muscles. As for the classification of the golf stroke, it was hoped that the general muscle action would provide some clues.

Using the reference points described above, an examination of the data (Figures 2-5) shows that the following muscles act over some portion of the driving phase of the stroke:

Triceps brachii, right arm	all subjects
Triceps brachii, left arm	all subjects
Right latissimus dorsi	all subjects
Right pectoralis major	three subjects
Posterior deltoid, right arm	three subjects
Posterior deltoid, left arm	one subject
Biceps brachii, right arm	one subject

On the basis of the general line of pull of these muscles, it seems probable that only the triceps of the right arm, triceps of the left arm, right latissimus dorsi, right pectoralis major, and the posterior fibers of the left deltoid contribute to the acceleration of the limbs

and club.[7] The posterior fibers of the right deltoid and the right biceps brachii probably function in a synergistic capacity.

Although all subjects show contractions from the right and left triceps during the drive stroke, there are extensive variations from subject to subject. It seems probable, however, that over the first part of the drive the triceps extends the arm and thus contributes to acceleration of the club. After extension of the arms, it is probable that the muscle action serves to keep the arms extended during the swing. In general, the triceps appears to function first in a driving and then in a supporting capacity.

All subjects show strong action of the right latissimus dorsi during the drive. The action of the latissimus is generally confined to the first half or two-thirds of the stroke; in this respect the contraction-movement relationships can be said to be like those of the typcial ballistic movement.

In all subjects mild contractions of the posterior fibers of the left deltoid generally commenced during the latter portion of the drive and continued into the follow-through. The late action of these fibers makes it obvious that the contractions do not contribute to the early rapid acceleration of the limbs and club.

In general, contractions of the right pectoralis major tend to occur sometime after the start of the drive and continue up to or beyond ball impact.

From the data of this experiment it would seem impossible to fit the golf stroke into the rubric of movement types. Analysis of the golf stroke indicates that the presumable driving muscles are in various stages of contraction and relaxation during the drive. Contractions from some of the presumable driving muscles are confined to the first part of the drive and are like the contractions of ballistic movements. Other muscles commence contractions well after the start of the drive and may drop out before ball contact, at ball contact, or during some phase of the follow through. There is extensive overlapping of contractions with the result that some muscle action occurs throughout the entire drive.

If one considers the total muscle action, it would appear that some positive muscular force acted throughout the drive phase of the stroke. This would indicate a movement of the non-ballistic type. It is also evident that the coordinations of the presumable driving muscles are quite unlike those of the traditional kinesiological analysis.

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[7]This analysis does not presume to be exhaustive. The data simply represent a determination of the probable driving muscles from a group of muscles accessible to experimental investigation. A detailed analysis would undoubtedly show that the compound impulse accelerating the limbs and club includes muscles involved in the "wrist snap" along with the deeper and less accessible muscles of the arm-trunk complex.

DISCUSSION OF RESULTS

For most of the muscles under investigation, the variations were extensive enough to preclude the formulation of any general statement that could be considered an accurate kinesiological analysis of the golf stroke. While the diversity of coordinations to accomplish the same functional end-result may at first seem without reason, there are several possible explanations. Individual differences in the size and distribution of muscles about a joint would conceivably result in different timing relationships. Variations in posture which change the line of muscular pull would result in different coordinations. Furthermore, a complex movement involves a large number of muscles and provides the possibility of different coordinations in the accomplishment of a movement sequence. In view of these possibilities and the common observation of the almost infinite individual variations in the performance of almost every human action, the experimental data would seem to indicate the impracticability of attempting to legislate any single or particular pattern of contraction-movement coordinations as being an accurate description of events occurring in the golf stroke.

Since experimental procedures did not permit a correlation of the contraction incidence with velocity changes, the true significance of the contraction-movement coordinations of the presumable driving muscles cannot be determined. On the basis of contraction incidence alone, it would appear that some positive muscular force acted throughout the drive. However, the mere fact of contractions throughout the drive may not represent positive muscle action up to the instant of ball contact. It is possible that the presumable driving muscles do not contract fast enough to exert continuous force on the limbs and that some part of the contractions simply function to take up muscle slack. During the latter part of the drive, the points of muscle attachment are being brought together rapidly, and to exert continuous force upon the limbs it would seem that a muscle must necessarily contract at an extremely high and continuously increasing rate. The action currents give no such curves of contraction. The fact that some of the presumable driving muscles contract well into the follow-through, when the limbs are decelerating, suggests that the moving limb outruns the muscle contractions. This, however, is simply a hypothesis and is in need of critical investigation.

While it is recognized that the scope of this investigation was too limited for any sweeping generalizations on the coordinations involved in the golf stroke, it is suggested that the experimental data do question many aspects of the traditional kinesiological analyses. When even so few as four subjects consistently indicate that the down stroke of the golf drive is initiated and driven by certain

muscles of the *right* arm, the time has arrived for traditional kinesiological analyses to seek experimental support for statements putting the initiating and driving force in the same muscles of the *left* arm. This can be said for other points of disagreement between experimental and traditional kinesiological analyses.

SUMMARY

Some contraction-movement relationships of the golf stroke were studied. By recording simultaneous action currents and movement tracings, it became possible to determine the incidence of muscle contraction and the probable function of each muscle.

The experimental results indicate that:

1. The contraction-movement relationships for the subjects of this experiment often vary widely from those postulated by the traditional kinesiological analysis.

2. While the contraction-movement coordinations of the individual subject proved to be surprisingly consistent, a comparison between subjects showed wide variations in timing and general coordination. For most of the muscles under consideration, the variations were extensive enough to preclude the formulation of any single statement which could be considered an accurate kinesiological analysis of the golf stroke.

3. From eighteen accessible muscles or muscle parts around both shoulder joints, it would seem that only the triceps brachii of right arm, triceps brachii of left arm, right latissimus dorsi, right pectoralis major, and posterior fibers of the left deltoid contribute to acceleration of the golf club.

4. Analysis on the basis of contraction incidence of presumable driving muscles alone seems to indicate that the golf drive is of the non-ballistic type. While some of the muscles act only over the first portion of the drive and are like contractions of the ballistic movement, other muscles commence action at various times after the start of the drive and continue up to or beyond impact. There appears to be extensive overlapping of contractions with the result that some muscle action occurs throughout the entire drive. Since experimental procedures did not permit a correlation of contraction incidence with velocity changes, the precise significance of the results cannot be stated.

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Marking in College Physical Education Activities

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(Submitted for publication March, 1948)

INTRODUCTION

THE problem of evaluating the work of individual students engaged in physical education activities is highly controversial and the practices employed are extremely varied. There is a great deal of dissatisfaction expressed against the use of marks in the entire field of education and their limitations are well known and critically viewed by teachers and pupils alike. It appears, however, that regardless of the dissatisfaction which exists, no satisfactory substitute has yet been found for the practice of marking.

PURPOSE

The purpose of this paper is to present a summary of marking practices now employed in some college and university physical education activity courses.

PROCEDURE

A questionnaire* was sent to a representative group of accredited colleges and universities throughout the nation. The selection of this group was determined as follows: (1) a group of twenty-five colleges and universities in the state of California; (2) a selection of one state university, a state teacher's college or the equivalent, and one private college or university from each remaining state; (3) eighteen Negro institutions; (4) the Universities of Alaska, Hawaii, and Puerto Rico, the United States Military Academy, and the United States Naval Academy.

Because several states do not have the number of accredited institutions as described, the writer selected additional schools from the District of Columbia, Illinois, New York, Ohio, and Pennsylvania. One hundred and ten returned questionnaires provide the basis for the data presented.

RESULTS OF THE STUDY

The system of marks employed by the various institutions

*A copy of this questionnaire will be found at end of article.

were as follows: (1) 20 schools use the pass or fail system; (2) 84 schools use the symbol system of A, B, C, D, and F or the equivalent; (3) 4 schools use a system of numbers, i.e., 60-99 inclusive or 1-100 inclusive; (4) 1 school employs a "credit" or "non-credit" system; (5) one school does not inform the student of his progress, and therefore no system of reporting marks is employed.

Factors considered in determining an individual's semester or final mark were selected and the individual institutions were requested to indicate the weight accorded these factors. The factors considered were as follows: attitude, attendance, costume, daily work, effort, healthmanship, improvement, oral examination, performance examination, skill, written examination and other factors not listed.

An analysis of these data indicated that the weight accorded the various factors was extremely varied. The only similar cases of weight given to factors were: (1) 3 schools which devoted one hundred percent to attendance; (2) 2 schools which gave one-third each for daily work, skill, and written examinations; (3) 2 schools which accorded the same weight to attitude, attendance, effort, improvement, and skill.

In the following table, a summary of this information illustrates the distribution of weight as reported by the responding institutions.

TABLE I

WEIGHT ACCORDED TO FACTORS USED IN DETERMINING STUDENTS' MARKS

Weight in Percent	Number of Schools Reporting											
	Attitude	Attendance	Costume	Daily Work	Effort	Healthmanship	Improvement	Oral Exam.	Performance Exam.	Skill (Subjective)	Written Exam.	Others
0	41	34	83	63	65	90	59	99	55	41	63	109
1 — 10	31	20	17	19	23	7	21	5	11	16	14	
11 — 30	17	15		12	11	2	20	2	16	21	19	1
31 — 50	4	19		6	1		3		15	12	7	
51 — 70		2							1	4		
71 — 90	11	3							2	2		
91 — 100		3								1		
Factors considered but weight not specified	16	14	10	10	10	11	7	4	10	13	7	
Total	110	110	110	110	110	110	110	110	110	110	110	110

Table I indicates that the majority of respondents gave weight to a number of factors when considering the final semester mark. Four institutions indicated that only one factor determines this; nine institutions indicated that two factors are considered; and fifteen institutions indicated that three factors are taken into consideration. Of those which consider three or less factors, attendance, performance examinations, and skill measured subjectively are the items most frequently used in determining the mark of a student. The remaining eighty-two respondents varied from a consideration of four to eleven factors.

The type of examinations that are conducted by the institutions is presented in Table II.

TABLE II

TYPE OF EXAMINATION EMPLOYED BY QUESTIONNAIRE RESPONDENTS

Examination	Number of Schools Reporting
A	9
B	28
C	0
A and B	46
A and C	0
B and C	2
A, B, and C	8
None	17
Total	110

A refers to the written examination.
B refers to the performance examination.
C refers to the oral examination.

The performance type of examination, or "B," is the most widely employed either singly or in combination. The oral examination, or "C," is not employed singly by any of the respondents. Those institutions using a combination of any two of the three suggested examinations employ the written and performance types, or "A" and "B," almost to the exclusion of any other possible combination of two. Eight institutions reported the use of all three examinations while seventeen indicated that no examination is employed as a basis in determining the mark of a student.

The responding institutions indicated thirty-one activities were tested by one or more of the three types of examinations. The performance examination was employed in 242 instances; the written examination was employed in 192 instances; the oral examination was employed in 12 instances.

Remarks accompanying the returned questionnaires indicated that the written examination is used primarily to test knowledge of rules. Comments concerning the performance examination indicate that this type is employed primarily as a means of determining

and testing individual skills and proficiency in individual activities and team sports.

Table III presents the information as to the criteria on which the student is marked. Space was provided on the questionnaire for other considerations, but none was listed. The writer assumes, then, that these criteria are most commonly used by colleges and universities.

TABLE III

CRITERIA ON WHICH STUDENT IS MARKED

Criteria	Number of Schools Reporting
A	16
B	17
C	24
A and B	8
A and C	16
B and C	10
A, B, and C	10
None	9
Total	110

A refers to student's standing with reference to the class.

B refers to student's standing with reference to an established skill or record.

C refers to the degree to which the student has approached his own maximum possibilities.

Criterion "C" received the greatest frequency among those respondents who indicated only one criterion was considered. There is a fairly even distribution of the combination of criteria with group "A and C" receiving more use than any other group.

A final consideration was the comparison of the distribution of physical education marks with the general distribution of marks in academic subjects within the institution. Fifty-five respondents indicated that the distribution of marks in physical education activities is the same as in other courses offered. Thirty-five replies indicated that the distribution contains more high marks than the general distribution of marks within the particular institution. Eight indicated that marks reported in physical education activities are lower than the general distribution of marks in other subjects. Twelve respondents did not complete this section.

SUMMARY

Specifically, the results of this study are as follows:

1. The majority of questionnaire respondents, or 84 institutions, use the A, B, C, D, and F method, or the equivalent, for reporting marks for physical education.

2. The weight accorded to the factors considered in determin-

ing marks (Table I) indicates that the majority of the institutions employ a number of factors when reporting the final mark.

3. Forty-six institutions employ a combination of written and performance examinations (Table II) in determining the mark of a student. Twenty-eight institutions reported the use of the performance examination while the oral examination is employed only eight times and then in combination with the other two.

4. Marking the student upon the basis of the degree to which he has approached his own maximum possibilities was found to be employed a slightly greater number of times than either of the other two criteria.

CONCLUSIONS

In conclusion, the results of this study indicate an amazing degree of variation, confusion, and contradiction in regard to theory and practice in marking physical education activities. This is illustrated by the fact that no two institutions considered in this study follow the same procedure in determining a student's mark. It is impossible, therefore, to determine from this information a basis for a reasonable evaluation of the work of students engaged in physical education activities.

RECOMMENDATIONS

As a result of the findings of this study it seems reasonable to recommend that this problem should be studied by a committee composed of leaders in the field of physical education and sponsored by the College Physical Education Association. The purpose of this committee would be to make a scientific study of this problem in an attempt to formulate a generally acceptable plan of marking men students in physical education activities. It is to be hoped that other approaches to this problem will be found in order to reach a solution that would be educationally and scientifically sound and defensible.

This study brought to attention the following considerations which a committee investigating the problem might take into account.

1. The purpose of marks in the physical education program at the college level.
2. The relationship of objectives of the college program of physical education and marks.
3. The determination of the most adequate devices of measurement and evaluation.
4. The criteria on which to base marks.
5. The acceptance of either the relative or the absolute method of awarding marks.
6. Determining the most effective method of reporting marks, i.e., A, B, C, D, and F or pass or fail.

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QUESTIONNAIRE

Name of Institution_____

I. A. Please check the number of years men are required to take physical education in your college or university: 0 — 1 — 2 — 3 — 4

B. Is credit toward graduation given for completion of physical education activities? Yes ( ) No ( )

II. Please indicate the system of marks used by your department for marking physical education activities.

A. Pass or Fail_____ Yes ( ) No ( )

B. Positive mark of A, B, C, D, and F or equivalent Yes ( ) No ( )

C. Other methods:_____

III. Please indicate approximately what percent of a student's semester mark is dependent upon the following considerations:

A. Attitude (enthusiasm or cooperative spirit) _____%

B. Attendance _____%

C. Costume _____%

D. Daily Work _____%

E. Effort _____%

F. Healthmanship _____%

G. Improvement _____%

H. Oral examination _____%

I. Performance examination _____%

J. Skill or proficiency _____%

K. Written examination _____%

L. Other considerations _____

_____

IV. If your department conducts the following types of examinations in physical education, please list below the activities in which such examinations are given:

A. Written examinations: _____

_____

B. Performance examinations: _____

_____

C. Oral examinations: _____

_____

V. Please check the following statements as they apply to your marking system:

A. In the matter of skill is the individual marked on the basis of his standing with reference to the average of the class?
Yes ( ) No ( )

B. Is the individual marked on the basis of his standing with reference to an established skill or record? Yes ( ) No ( )

C. Is the individual marked upon the basis of the degree to which he has approached his own maximum possibilities? Yes ( ) No ( )

D. Other considerations: _____

_____

VI. How does the distribution of marks in physical education conform to the normal distribution of marks in your institution generally?
Same ( ) More High Marks ( ) More Low Marks ( )

VII. Do you desire a summary of the returns of this questionnaire?
Yes ( ) No ( )

Present Status of Women's Physical Education in California Junior Colleges

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(Submitted for publication February, 1948)

A SURVEY of the status of physical education for women in the junior colleges of California for the academic year, 1946-1947, was made by the writer. It was the purpose of the survey to study certain areas of existing programs, such as academic status of physical education, teaching policies and practices, equipment, and activities.

The physical education department heads of fifty-six junior colleges, both public and private, were sent questionnaires*; forty-four replied, thus furnishing information on seventy-nine percent of all California junior colleges. Of these forty-four responding, it should be noted that only forty schools have departments of physical education for women.

It is axiomatic that the socio-economic implications of physical education programs for terminal women students in California junior colleges cannot be overemphasized. This particular level of education is one which has grown so rapidly that many problems peculiar to such growth remain as yet unsolved.

The insistent and ever-expanding demand for education beyond the secondary level has resulted not only in the simple growth of schools, but in an entirely new concept of education for democratic living. It is now assumed that women, and men also, must engage in recreational sports as part of the complete democratic life. Thus, the rise of the junior college as a publicly financed opportunity for universal higher education is a challenge to educators in all fields of learning.

The present study set out to find just how adequately this challenge is being met by physical educators today. Since the number of women enrolled in California junior colleges for the academic year 1946-1947 ranged around 22,000, the consideration of their training becomes most important. First, if play is training in socialization, are we teaching the activities that hold the most promise for socialization?** Are we making it possible for each

*A copy of this questionnaire will be found at end of article.
**A list of activities offered to women in California junior colleges in 1946-47 will be found at end of article.

student to experience the social process in physical education which makes his full attainment of maturity a reasonable expectation? Second, are we making the physical education program so meaningful and satisfying for the student that her response is one of lasting interest in and desire for physical activity? Third, are we helping to produce, through physical education, integrated personalities for effective living in a democratic society?

With these considerations in mind, the following conclusions were drawn from the study:

1. Size of classes and teaching loads throughout the state are both commensurate with optimum junior college standards. There is no need for over-all improvements here, although in a few instances there still remain problems.

2. One-half of all California junior colleges must still work toward separate gymnasia for women. With this objective realized, many problems arising from shared facilities will be eliminated.

3. Within the last decade, there has been a rapid increase in the number of coeducational physical education classes in the junior colleges. Although impetus in the latter half of the decade was given by the lack of men instructors during the war, and the practice was actually a solution to the problem of understaffing, this explanation is not the most important one. Physical educators as a whole, feel that opportunities for socializing through game situations should be provided as a necessary experience in the development of personalities. The coeducational playday, which is an outgrowth of coeducational physical education classes, is perhaps one of the most valuable additions to the socializing process that physical education has contributed in the last decade.

4. Facilities such as showers, dressing rooms, rest rooms, and classrooms are adequately provided in the majority of junior colleges. Inadequacies exist here, also, however, in those schools with shared gymnasia.

5. There is still a definite need for dance studios and/or exercise rooms for junior college physical education departments. There is a psychological factor involved here that should be recognized by the provision of a specially set up room for both of these activities. The dance and exercise programs should be set apart from the atmosphere of active athletic games and large gymnasium activities. In certain colleges throughout the country, modern dance is not only being separated in space from the physical education department, but in theory also. Many dance departments are now parts of the fine arts section.

6. The provision of sundecks as standard equipment for all junior college physical education departments should be urged. This

procedure is sound from the standpoint of health as well as possessing many positive factors from the point of view of taking care of students who have disabilities more constructively dealt with by sun and fresh air than by confined rest indoors.

7. Swimming pools are needed in three-fourths of all junior colleges, and many of the existing pools should be brought up to adequate standards in filtration and heating systems. The problem of procuring a swimming pool in a public junior college is largely a community concern, and the physical educator teaching in that school is the logical person to begin a campaign to this end. In such pools as there are, women are receiving a very small portion of the class time.

8. The problem of tennis courts is not acute, but approximately one-fourth of the schools still need them. The most persistent problem in this case, as in all shared facilities, is the unequal allotment of time for women.

9. The existence of badminton courts in junior colleges is almost universal. The only reform needed here is that of allowing women to use the courts that are already provided.

10. Almost all junior colleges are well provided with outdoor, turf playing fields.

11. With turfed playing space available in nearly all junior colleges, more should be done with golf. This sport is one of the best carry-over activities and the teaching equipment costs no more than for archery.

12. More constructive thinking and planning must be directed toward the problem of restricted students. Productive programs for this group cannot be planned in a one-teacher department unless administrative help is solicited. Perhaps the only solution lies in planning physical examinations before allowing students to sign up for classes. In most schools, the services of the physician are not secured until after registration; this usually results in the scattering of restricted students in all activity classes. When this occurs there is no opportunity to set up restricted programs and supervise them. The only possible way out of this difficulty is to schedule an extra two hours a week and shift all restricted students from the classes in which they were signed to the new hours. This could be done after physical examinations, some time within the first two weeks.

13. Although the use of community facilities by some junior colleges indicates an encouraging rapport between schools and community, this means of dealing with inadequacies of the plant should not be used indefinitely. Each department should bend all efforts toward the construction of permanent facilities on the school grounds.

Status of Physical Education for Women in California Junior Colleges

Name of school _____

Number of women students _____ Number of instructors _____

Average size of classes _____ Size of smallest class _____ Largest _____

I. Facilities:

Do you have a gymnasium of your own _____ or is it shared with men? _____ If your gymnasium is shared, how many hours per week is it used for women only? _____ How many hours of coeducational activity per week? _____ Do you have a rest room where girls may stay during inactivity? _____ Is it equipped with beds? _____ If so, how many? _____ A lavatory? _____ Do you have central showers? _____ How many heads? _____ Do you have individual showers? _____ How many? _____ How many individual dressing rooms do you have? _____ If you have central showers, do you have just one large dressing room? _____ Does your gymnasium have a classroom? _____ How many chairs? _____ Does the classroom have a blackboard? _____ Do you have a dance studio? _____ An exercise room? _____ Both? _____ Do you have a sun deck? _____ If not, have you any plans for one? _____ Have you a rifle range? _____ Indoor _____ Outdoor _____ Have you a swimming pool? _____ Indoor _____ Outdoor _____ Heated? _____ Filter system? _____ What is the size of your pool (in feet)? _____ What are the depth levels? _____ Is the pool shared with the men? _____ If so, how many hours per week is the pool reserved for women? _____ How many hours per week is your pool used for coeducational activity? _____ How many tennis courts do you have? _____ Asphalt? _____ Clay? _____ Are these courts shared with the men? _____ If so, how many hours per week are the courts reserved for women? _____ How many hours of coeducational tennis classes do you have each week? _____ How many badminton courts do you have? _____ Indoor? _____ Outdoor? _____ Are they shared with the men? _____ How many hours for women only? _____ How many hours of coeducational badminton per week? _____ Do you have any outdoor playing fields? _____ How many? _____ Surfaced? _____ Turfed? _____ Unsurfaced? _____ Do you have a putting green? _____ Space for one? _____ Have you an archery range? _____ Number of bows _____ How many targets do you have room to set up on your range? _____

II. Range and Status of Physical Education Activities:

Please check the sports listed below. Use (R) for required, (X) for offered, (C) for coeducational, or any combination of the symbols.

Archery	___	Golf	___
Badminton	___	Hockey	___
Baseball	___	Riding	___
Basketball	___	Riflery	___
Body mechanics	___	Speedball	___
Dancing:		Soccer	___
Folk	___	Swimming	___
Modern	___	Tennis	___
Clog	___	Table tennis	___
Social	___	Trampoline	___
Fencing	___	Volleyball	___

III. Teaching Aids:

Do you have a movie projector? _____ A piano? _____ A phonograph? _____ A public address system? _____ Do you use movies as teaching aids? _____

IV. Teaching Policies and Practices:

Are your students allowed elective activities in physical education? _____ Do you have a required freshman activity program? _____ Are your students allowed to elect just one sport for the entire two years? _____ For the sophomore year? _____ Is your activity program slanted toward the development of skill in individual or cooperative sports, with the terminal student in mind? _____ Do you have any specific provision for the terminal student in connection with her choice of activities? _____ Is she allowed more freedom of choice? _____ Are your classes arranged on a seasonal basis? _____ Are students who are classified as restricted given first choice or consideration in the scheduling of classes? _____ Is guidance in the selection of physical education activities based on the findings of the health examination *and* on previous experience and interests? _____ Is this possible? _____ Have your students ever taken part in a coeducational playday? _____ What is the student response to your physical education program? _____ Do you have an attendance problem? _____ Do you make use of any community facilities in order to enlarge your activity program? _____

ACTIVITIES OFFERED IN THE PHYSICAL EDUCATIONAL PROGRAMS FOR WOMEN IN CALIFORNIA JUNIOR COLLEGES—1946-1947

Sports	*Percentage of Schools Offering*	*Number of Schools Offering*	*Number of Schools Requiring*	*Number of Schools Coeducational*
Badminton	95	37	6	10
Basketball	87	34	5	2
Volleyball	87	34	4	3
Tennis	84	33	4	6
Archery	79.5	31	4	6
Baseball	77	30	3	3
Body Mechanics	69	27	8	2
Dancing (all)	69	27	4	
Folk Dancing	59	23	5	2
Hockey	56	22	2	0
Swimming	51	20	3	1
Speedball	46	18	2	0
Modern Dance	43	17	2	0
Golf	41	16	2	5
Table Tennis	41	16	1	3
Social Dance	41	16	1	8
Soccer	23	9	0	1
Riding	20	8	0	1
Clog Dance	13	5	0	0
Fencing	10	4	0	0
Bowling	7	3	0	1
Trampoline	5	2	0	2
Riflery	5	2	0	1

The Present Status of Health and Physical Education Programs in Negro Senior Colleges

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(Submitted for publication March, 1948)

STATEMENT OF THE PROBLEM

It was the purpose of this study (1) to evaluate the physical education programs and the general health, recreation, and safety provisions of Negro colleges in terms of accepted standards; (2) to compare private and public Negro institutions; (3) to determine the relationships between expenditures, personnel, facilities, and program efficiency; and (4) to offer upon the basis of these facts constructive proposals for changes and improvement as a guide in postwar planning should the need for it become evident.

Negro colleges have become an important part of America's educational system. Besides its place in the field of general education for Negroes, the Negro college occupies the unique place of being the source of leadership and guidance for the race. The problem of health and recreation, therefore, is important in Negro education. To what extent Negro colleges are fulfilling or can fulfill their obligations can be determined only by a study of this nature.

Furthermore, the fact that a national campaign has been undertaken to secure funds for the improvement of private Negro colleges and the trend toward expansion of publicly supported institutions for Negroes seem to indicate the need for such a study. Facts concerning existing conditions in all aspects of the program must be made available as a guide for efficient planning of improvement.

REVIEW OF LITERATURE

There are comparatively few studies dealing with any phase of the health and physical education programs in Negro colleges. In fact no data are available with reference to physical education expenditures or on the relationship of expenditures to the service in this field.

The United States Office of Education (4) made an extensive survey of Negro education. However, certain aspects of the physical education, recreation, health, and safety programs which are essential to any plan of reconstruction in this important phase of the colleges' services were omitted. Studies made by Ellis (5), Cornely (3), Taylor (13), Rogers (10), and Neilson (9) contributed to

certain phases of this investigation with reference to health practices and types of activities being conducted.

METHOD OF PROCEDURE

Modification of LaPorte Score Card.—The LaPorte Health and Physical Education Score Card No. II, which is primarily designed for evaluating secondary school programs in health and physical education, was slightly modified so as to be adaptable for college use. For example, in Section IX, item six which deals with teacher class assignments the phrase "twenty clock hours per week" was inserted in place of "seven clock hours per day," "eighteen clock hours per week," in place of "six clock hours per day," and "fifteen clock hours per week," in place of the original "five clock hours per day."

The various phases of the physical education program covered by the score card are: (1) program of activities, (2) outdoor areas, (3) indoor areas, (4) locker and shower areas, (5) swimming pool, (6) supplies and equipment, (7) medical examination and health service, (8) modified-individual (corrective) activities, (9) organization and administration of class programs and (10) administration of intramural and intercollegiate athletics.

Supplementary Check List.—This modified form of the LaPorte score card was supplemented by a check list designed to obtain additional information considered necessary to this study. The information desired was concerned with the total expenditures for health and physical education, the percent of the total budget allocated to such areas as health service, the instructional program, intramural sports, and intercollegiate athletics. The check list was also intended to ascertain the number of days per week part-time physicians are available and the number of instructors in the physical education department together with the degrees held by each.

Collecting Data.—These materials were mailed to the deans of the colleges being studied by the dean of Southern University, Baton Rouge, Louisiana. This procedure was used because of administrative interest in the results of the investigation inasmuch as it is concerned with problems of instruction and administration definitely related to the total college program. Too, it was felt that this method of seeking the information would tend to focus the attention of college administrators upon this generally neglected phase of Negro college programs.

A letter of transmittal explaining the purpose of the investigation was included with the materials sent out. The investigator followed up this procedure by sending letters to the physical education directors requesting their cooperation in securing the data and included a copy of the letter which had been sent to the respective college deans. In addition, follow-up letters were mailed out by the

dean of the university and the investigator. Personal visits were made to thirteen colleges in seven of the states and a thorough study was made of the bulletins issued by each institution included in the sample.

Reliability of the sample.—Forty-eight senior colleges for Negroes were sent copies of the score card and check list. In an effort to secure a satisfactory sample, private and public schools of varying sizes located in nineteen different states were included in the study. The *Negro Educational Directory for 1943-44* lists seventy-seven colleges of senior classification. Of this group of colleges 57 percent are private institutions, while 43 percent receive public support. Included in the sample of forty-eight colleges, 48 percent are of the private classification and 52 percent are publicly supported colleges. The fact, too, is to be recognized that the great majority of Negro colleges are located in the seventeen southern states where three-fourths of the Negro population lives.

Replies were received from 31 institutions, or 65 percent of the schools contacted. The group replying included seventeen public colleges and fourteen private colleges. Twenty-five of the replies were usable and represented colleges in fifteen states. The states geographically are located in the Midwest, Southeast, and Southwest.

The question arises as to the reliability of the sample as represented by the group replying. This question is of particular importance since mailed questionnaires were used and it has been shown that those who returned questionnaires can be atypical (11, 12). In view of this problem an analysis was made of school bulletins and other literature (6, 8) with reference to certain items common to college administration which would serve for checking the reliability of the sample. The items selected were educational expenditures, enenrollment, and classification (private or public).

In comparing the two groups with reference to expenditures, enrollment, and resident tuition, the t-ratio was used because of the small samples involved (7).

The chi-square technique was used in the comparison of the two groups in terms of classification (public or private). The data in Table I show that of the items studied the two groups were significantly different only with respect to total educational expenditures. This seems to indicate that colleges with comparatively better budgets are more likely to reply in studies of this kind than are colleges with lower budgets. This factor should be kept in mind in interpreting the results of this study.

Analysis possibilities.—In comparing the private and public colleges the most obvious method would be to test the significance of the difference in the percentages based upon the total scores. This

percent score for the private colleges on program of activities, for example, is 51 percent; for the public colleges it is 60 percent. Based upon eight and seventeen cases, respectively, the critical ratio of the difference between these percentages is .43. This particular critical ratio would lead one to conclude that there is no real difference between the private and public colleges with respect to program of activities.

TABLE I

RELIABILITY OF THE SAMPLE

	Total Group	*Sample*	*P*
1. Total educational expenditures	Mn = $165,977 S.D. = 4,440 N = 41*	Mn = $183,321 S.D. = 4,447 N = 25	<.05
2. Enrollment	Mn = 577 S.D. = 111.00 N = 47**	Mn = 728 S.D. = 120.00 N = 25	>.05
3. Resident tuition	Mn = $80.00 S.D. = $35.32 N = 48	Mn = $73.00 S.D. = $32.15 N = 25	>.05
4. Classification	Private = 23 Public = 25	Private = 8 Public = 17	>.05

* Data not available for 7 of total group.
** Data from one school not applicable.

There is another way of approaching this problem which might reveal a significant difference between the two groups of colleges. The total score is based upon ten items. Because of the small number of cases there will hardly be any significant differences on each individual item, such as "content of core program." However, if chance were operating one would expect private colleges to be higher on one-half of the items (5) and public colleges to be higher on one-half of the items (5). Therefore, are all deviations from this 5-5 division chance deviations or are they significant deviations? This can be determined by the chi-square technique. For example, in the ten items on program of activities the public colleges had a higher percentage on nine items, whereas the private colleges were higher only on one item. This 9-1 observed deviation from the expected deviation of 5-5 is a significant one since the value of chi-square is 4.9.

This method of analysis is used for all of the data from the score card. In calculating these chi-squares the correction recommended by Guilford (7) was used in which .5 is deducted from each of the observed-expected values.

FINDINGS

From an analysis of the data in this investigation the following facts were revealed:

1. Only meager relationship exists between total expenditures

and the over-all efficiency of the program. The correlations are listed in Table II.

2. A small amount of relationship or slight negative relationship exists between personnel, teaching load, student enrollment, and certain factors concerned with program efficiency. The correlations obtained are listed in Table III.

3. Twenty percent of the colleges studied did not have gymnasiums and 40 percent only met approximate standards. The gymnasium areas in the remaining 40 percent of the colleges are improvised facilities and do not approach acceptable standards. Particularly noticeable were the inadequate number and sanitation of shower, locker, and toilet areas.

4. The public colleges, although below acceptable standards, were better than the private institutions on indoor facilities.

5. Eighty-four percent of the colleges did not meet the standards required for an adequate safety education program.

6. The majority of the schools lacked sufficient outdoor space for an acceptable physical education and recreational program. Court areas for dual and individual sports were particularly lacking.

TABLE II

RELATIONSHIPS BETWEEN BUDGETARY ALLOCATIONS AND FACTORS CONCERNED WITH PROGRAM EFFICIENCY

Allocations	*Factors*	*Correlations*
Total Budget	Enrollment	.75 ± .10
Total Budget	Program Efficiency	.33 ± .14
Instructional Budget	Program of Activities	.41 ± .13
Instructional Budget	Organization and Administration of Class Program	.29 ± .14
Instructional Budget	Supplies and Equipment	.45 ± .12
Health Budget	Enrollment	.66 ± .91
Health Budget	Health Service Efficiency	.01 ± .01
Athletic Budget	Administrative Efficiency	.29 ± .14

TABLE III

RELATIONSHIP BETWEEN CERTAIN FACTORS CONCERNED WITH PROGRAM EFFICIENCY

Factors	*Correlations*
Enrollment—Number of Instructors	.67 ± .07
Program Efficiency—Number of Instructors	.36 ± .14
Enrollment—Locker and Shower Areas	.11 ± .13
Enrollment—Indoor Facilities	.20 ± .10
Enrollment—Outdoor Areas	.18 ± .13
Teaching Load—Organization and Administration of Class Program	—.22 ± .12

7. Ninety percent of the colleges make no provisions for gymnasium suits, towels, laundry services, or equipment clerks. Such provisions are the responsibility of the individual student.

8. Full-time physicians are employed in only 16 percent of the colleges; part-time physicians make daily visits in 28 percent, and regular visits once, twice, or three times per week in 16 percent. Physicians make only "emergency calls" in 32 percent of the institutions.

9. Full-time nurses are employed in 76 percent of the colleges; public colleges also make better provisions in this respect.

10. While the great majority of the colleges had adequate supplies and provisions for conducting intercollegiate athletics, they were below standard in the matter of providing for intramural sports.

11. A large proportion of the colleges, 57 percent, sponsor intercollegiate athletics for women.

12. In the great majority of Negro colleges it is the common practice to either assign students for unlimited physical education participation or to completely exempt them upon a written statement from a physician. Restricted activity or corrective physical education are not common phases of Negro programs. Forty-five percent of the colleges made no provisions of any type for restricted programs while 36 percent made inadequate provisions to meet minimum standards.

13. A large number of physical education directors, 72 percent, also devote time to coaching one, two, and in some instances, three sports.

14. There were no statistically significant differences in programs of colleges where the physical education directors also coached, where the physical education directors devoted full time to physical education as such, where the director had a minimum of training, and where the director had much advanced training. Case comparisons are listed in Table IV and Table V.

15. Of the ten sections of the score card evaluated, the public and private colleges were significantly different only on indoor areas and program of activities. These differences favored the public colleges.

CONCLUSION

The data presented in this study indicate that Negro colleges have a highly mixed, heterogeneous situation with respect to physical education programs—a situation running from little or nothing to some good programs. Furthermore, these colleges, in practically every criterion, differ a great deal among themselves. Possibly one factor contributing to this great variability is concerned with the local aims of each physical education department. Some schools have compara-

TABLE IV

COMPARISON OF COACHING DUTIES OF PHYSICAL DIRECTORS UPON THE EFFICIENCY OF THE PROGRAM

Coaching Duties	*Enrollment*	*Budget*	*Teachers*	*Degree*	*Experience*	*Sections Excelled*	*Program Score*
1. *Yes*							
School A	919	24,276.89	6	MS	10 yrs.	7	186
School B	850	45,045.00	6	MS	10 yrs.	7	177
2. *No*							
School A	877	21,478.28	6	MS	10 yrs.	3	125
School B	752	12,418.58	6	MS	10 yrs.	3	144.5

Note: This table should be read as follows: each school in Case Number 1 and Case Number 2 are comparatively equated on items of enrollment, budget, number of teachers, and physical directors with some academic training and ten or more years of experience. In each school listed under Case 1 the director coaches two or more varsity sports, and the schools excel on seven sections of the score card. In each school listed under Case 2 the directors devote full time to physical education and the schools excel on three sections of the score card. Chi-square of .90 shows difference in programs is not a significant difference. Chi-square is based on seven out of ten items.

TABLE V

COMPARISON OF TRAINING AND EXPERIENCE OF DIRECTOR OF PHYSICAL EDUCATION UPON THE EFFICIENCY OF THE PROGRAM

Directors Training-Experience	*Enrollment*	*Budget*	*Teachers*	*Sections Excelled*	*Program Score*
1. *MS Degree*					
School A—20 yrs.	586	21,000.00	2	2	141
School B— 8 yrs.	560	7,840.00	2	2	99
School C—11 yrs.	800	8,714.00	2	2	138
Av. 13 yrs.	1,946	37,554.00	Av. 2	Av. 2	378
2. *BS Degree*					
School A— 6 yrs.	534	13,610.00	2	7	121
School B— 8 yrs.	935	11,840.00	2	7	146
School C— 5 yrs.	463	10,964.00	2	7	183
Av. 6 1-3 yrs.	1,932	36,414.00	Av. 2	Av. 7	430

Note: This table should be read as follows: each school in Case 1 and Case 2 are comparatively equated on items of enrollment, budget, and number of teachers. The physical directors in each school listed in Case 1 have masters' degrees and from eight to twenty years of experience and excelled on two sections of the score card. The physical directors in Case 2 have bachelors' degrees and from five to eight years of experience and excelled on seven sections of the score card. Chi-square of 1.76 shows difference in programs is not a significant one. Chi-square is based on seven out of nine items.

tively good gymnasiums and fairly adequate staffs and are concentrating more or less on professional courses in physical education. Some have poor facilities and probably place emphasis upon certain intramural sports in keeping with the limited facilities. Too, in many instances it is obvious that, regardless of staff or facilities, the major interest is being placed upon intercollegiate athletics. Furthermore, there are institutions in which all phases of physical education re-

ceive meager or no attention. It is obvious that great variability in what exists tends to make for great variability in what the present programs are trying to do.

Analysis of the data in all aspects of the program point to four basic problems influencing the present low standards of physical education in Negro colleges:

1. Limited funds, both budget and capital outlay.
2. Inadequate facilities (related to first item).
3. Inadequate number and training of most of the instructors.
4. Attitude of the college administration toward the program of health and physical education.

It was easily noticeable, however, that the lack of suitable facilities had more effect upon low ratings in various phases of the program than any one single factor.

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Athletic Injuries Among Adolescents: Their Incidence and Type in Various Sports*

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THE frequency and kind of injuries which occur in various types of athletics are of particular concern to those who operate student health services or student athletic programs, and are of interest to those family physicians and specialists whose advice is sought in connection with the incidence, prevention, or management of those injuries. Athletics and participation in them play a large part in the life of the boarding school boy and in such a situation there is a good opportunity both to determine what sports are most hazardous and what injuries most frequently occur, and also to learn what to expect and what to attempt to prevent. This report gives the numbers and kinds of injuries which occurred in a group of approximately 650 boarding students at a boys' preparatory school over a period of seven years. The ages of these students range from thirteen to eighteen years.

At this institution all students are required to participate in athletics. There is a compulsory program of sports for from seventy-five to ninety minutes on four days a week and this is supplemented (during the fall and spring) by a relatively strenuous period of body-building exercises, or calisthenics (5, 6) which lasts from fifteen to twenty-five minutes. In addition, there are frequently competitive games for team members on two other days in the week. Practically all students participate in this program. An appropriate sport is found for almost every boy even though a severe grade of some chronic disorder may be present, and those who have had acute illnesses or recent injuries are quickly returned to some proper form of exercise. In any interpretation or comparison of this type of data it is important that the attitude of the health service toward athletics be understood (4). This health department fully believes in athletics as a means of developing endurance, strength, agility, and coordination and of fostering certain desirable personality traits, and gives the athletic program full support. The

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health service does, however, attempt to use every reasonable method to prevent illness or injury in athletics and attempts to spread the doctrine that a boy who is in good condition is much less likely to be "strained" (4) or injured and much more likely to be benefited by his athletics than is one who is not. One of the reasons for instituting this school's body-building program (5) was to improve the condition of those who would inevitably be participating in strenuous sports.

Mention should be made of some of the regulations which are enforced as part of the accident prevention program. No one participating in soccer, football, hockey, basketball, baseball, or lacrosse may wear eye glasses unles they are equipped with "unbreakable" lenses. Football players known previously to have had knee injuries must do exercises to strengthen their quadriceps and vastus medialis muscles (9, 1) and be protected with "Duke Simpson" strapping (9). All football players are taught properly to apply muslin ankle wraps (7) over their socks, and must do this daily. Special pains are taken to see that football equipment (helmet, shoulder pads, etc.) fits properly. Hockey players must wear helmets. Lacrosse players must wear masks. Of no less importance than the enforcement of these regulations is the attention to cleanliness of equipment, the use of proper drinking fountains or individual cups, and most of all the eternal vigilance of the trainer and coaches in quickly removing from play anyone who is obviously tired or even slightly injured. The importance of the trainer in the accident prevention program cannot be exaggerated; a man in this position who is not alert, not forceful, not capable, and not completely cooperative can ruin the best efforts of any health department. Valuable suggestions regarding these matters can be found in the publications of Stevens and Phelps (8) and Thorndike (9).

It should be emphasized, prior to the discussion of data relating to injuries, that this report is not concerned with the relative merits of the particular sports. This report attempts only to indicate, on the basis of experience in this institution, what injuries one may expect in connection with various types of athletics, and to suggest in what directions efforts to prevent injuries should be directed. In the tables the football injuries are divided into three groups: those occurring in varsity eleven-man football; those in junior varsity eleven-man football; and those in six-man football. The varsity group has on the average 48 members; these boys have the most ability, the best coaching, and the best equipment. The junior varsity group is almost twice as large and is made up of less skilled and in general younger boys. Six-man football (2), a game involving much less body contact than the regular American

eleven-man football but excellent for improving skill in running and in passing the ball, was added to this institution's athletic program in 1940 in an effort to prevent injuries among those younger or less mature boys whose state of development or degree of skill was not suitable for the more dangerous game. It is not difficult to convince a tall, lean boy whose joints are as yet poorly supported and protected that he is more likely to be able to play eleven-man football later if he will keep away from it until his development has reached the point where it will be a safer game for him. However, it is impossible to convince him unless the varsity coaches are cooperative and have learned that many boys who might be good players later on are lost to the game because they started playing it in a strenuous manner before their muscular and skeletal develpoment made it reasonably safe for them to do so. In sports other than football all participants' injuries are grouped together; in these no distinction has been made between those occurring in members of varsity teams and those of less skillful players.

RESULTS AND DISCUSSION

In Table I* is shown the total number of major and minor injuries which required attention at the school hospital or at its out-patient department during the years 1940 through 1947. During the years 1940 and 1941 no records were kept of injuries occurring in some of the sports. Tennis, fencing, golf, and swimming are omitted from this and the following tables because there was only a total of three minor injuries in the first three sports and only four injuries in swimming during six years.

There is little variation in the number of participants in each sport from year to year and the range of number of participants and the number of participants for each year have been omitted from the tables. The average number of participants is a reasonably accurate figure and is sufficiently so for purposes of comparison. The relatively large number of weeks assigned to the track season is due to the fact that this sport extends throughout the school year; it has a much larger number of participants, however, in the winter and spring.

The total number of injuries and the average number of injuries in each sport are of no value in comparing one sport with another but are of some interest in themselves from the standpoint of predicting what one may expect. By including the 1941 data for soccer and football the figures for six complete school years may be obtained; there was a total of 690 injuries or about one injury per boy every six years. When one considers that the injury total in-

*Tables will be found at end of article.

cludes many minor as well as major injuries the number does not seem excessive.

On the comparative basis of average number of injuries per participant per year there is little difference between soccer, basketball, hockey, wrestling, baseball, and lacrosse. Basketball had the least injuries of these and baseball the most. Track, as might be expected, had fewer injuries per boy than any of those. That baseball had more injuries than lacrosse may surprise those who have seen lacrosse played. It can be explained by the facts that lacrosse as played in preparatory schools (at least in New England) is strictly refereed in an effort to keep injuries down; and because the obvious roughness is not of the kind which frequently produces injuries; to slash at your opponent's stick may seem dangerous to a spectator but it only rarely injures a player. The number of eleven-man football injuries averaged more than eight times as many as for hockey and lacrosse, but in six-man football there were only about one and a half times as many as in those games.

There is a considerable year-to-year variation in the number of injuries in each sport. Some of this is undoubtedly due to chance, but often it has seemed that it is the least skillful and least successful teams which have the most injuries. Manner and effectiveness of coaching, quality of equipment, attention to detail, and degree of emphasis on winning are all factors which contribute to the number of injuries. Each year there should be a review of results and an effort to correct the probable causes of injuries.

Major injuries have been arbitrarily defined as those which caused an absence of ten or more days from participation in athletics. This division of all injuries into two categories allows one to determine the incidence of injuries of considerable significance in each sport. In a boarding school situation many injuries of little moment (and which would not be brought to the attention of a family physician were the boy at home) are reported to the health department. Whether or not these injuries are reported frequently depends as much upon the personality of the individual as upon the severity of the injury. Table II gives the number of major injuries which occurred in various sports over a period of several years, the average number of major injuries in each sport per year and the average number of major injuries per participant per year. There were no major injuries in fencing, swimming, tennis, or golf. Track, despite its large number of participants and the hazards which javelin, weight throwing, pole vaulting, and high jumping present, had only one major injury in each of six years and none in the other year. Soccer, hockey, wrestling, and lacrosse all had very few major injuries during this period, and there was little

difference in the number per participant in these sports; basketball had fewer injuries than any of those and baseball had about twice as many. Varsity football had the highest incidence of major injuries per player, and junior varsity football was next; these two averaged more than twenty times as many major injuries per player as did soccer or lacrosse. Six-man football, although it produced about four times as many major injuries per player as soccer, had only one-fifth as many major injuries per player as varsity and junior varsity football.

Another useful means of comparing the injuries which occur in various sports is a tabulation of the number of hospital admissions which these injuries required (Table III). In a boarding school situation there will be many more hospital admissions than would be the case were the students living at home. All concussions and most severely sprained ankles are admitted to the school hospital, but very few of these would enter a general hospital were they living at home. Many such injuries are, either as a precautionary measure or in an effort to decrease the period of recovery, admitted to the hospital for an overnight stay. For these reasons the number of hospital admissions is about twice the number of major injuries. Eleven-man football and six-man football exceeded all other sports in the number of hospital admissions; track had the smallest number, basketball and hockey were next, and soccer, lacrosse, wrestling, and baseball had about an equal number of admissions per participant.

The number of hospital days spent is of value in estimating the relative severity of the injuries which occurred in the different sports and is important in determining which sports cause students the greatest loss of time from their studies. Table IV gives the average number of hospital days spent per participant in each of the sports. Although the average number of days spent in the hospital per player is highest in the varsity football group, it amounts to less than one hospital day per player each season on the average, and in only one year (1941) was this average considerably exceeded. Again a considerable difference between eleven-man and six-man football is evident. The former averaged more than twice as many hospital days for its injuries. Lacrosse, which has been shown to have had relatively few minor or major injuries, had a comparatively large number of hospital days. This was due in large part to one injury (a fractured femur in 1944), but it is reasonable to expect one such incapacitating injury every few years. In this connection it is well to remember that severity of illness cannot always be judged by length of hospital stay; a fracture of the tibia and fibula which requires no more than a week's hospital care is hardly one-eighth

as severe as a fracture of the femur. Basketball injuries required the least hospital days per player, and there was little difference between the small average numbers required by the members of the hockey, track, wrestling, and baseball teams. During the six school years from September, 1941, through June, 1947, about six percent of the total hospital admissions were on account of athletic injuries and about five percent of all the hospital days spent were from the same cause.

Table V lists the types of injury which were reported in the various sports during seven consecutive school years (with the exception of the soccer injuries of 1941) and an additional year's football injuries. In the interest of brevity there has been an effort to group diagnoses and to make them as simple as possible; for example the knee injuries have been put into either one of two categories and lacerations of other than the face or scalp, and various muscle strains have been listed as "miscellaneous." It is clear that all injuries which occurred were not reported; there were certainly more contusions of the testes than one and more finger sprains than twenty-four But it is unlikely that any injury of any significant degree of severity was not reported. It is also proper to assume that almost all injuries which are tabulated were more than trivial. The sprained fingers were sufficiently injured so that fractures were suspected, the quadriceps contusions were incapacitating, and any nose contusion recorded was worthy of an x-ray.

The summaries (Tables V and VI) permit one to select those injuries which occur so frequently that every effort should be made to present them. Outstanding because of the possibility of their after-effects as well as their immediate damage are the knee and head injuries which occur in football. To control the former there should be the following.

1. A vigorous program of calisthenics prior to and during the football season.
2. An attempt to exclude from the game those whose state of development and linear build make their knees more vulnerable.
3. Use of proper supporting bandages by those who have had even slight ligament injuries.
4. Strengthening of the quadriceps and vastus medialis by supplementary exercise (6, 9, 1).
5. Encouragement of all methods which tend to keep players alert at all times.

Head injuries are difficult to control; the best in helmets and the proper fitting of helmets is the least, and perhaps the most, that can be done. Nose fractures are common and little can be done to prevent them. Finger fractures and sprains are very common and it is suggested that attempts to strengthen the hands might be helpful. Ankle sprain was the most common injury of all; exercises designed specifically (6, 9, 1) for their strengthening and the insistence that all players learn how properly to apply ankle wraps (7) and that they wear them at all practice sessions and games should help to reduce these injuries. Quadriceps contusions are common and are most likely to occur where the protective pads are not properly fitted. There were few epiphyseal injuries. The sprinter's fracture furnishes a good example of the importance of avoiding too great strain on immature youths, particularly before they have been well trained in, and well conditioned for, their particular sport. The enforcement of the regulation regarding the use of only unbreakable lenses in eye glasses bore fruit; there was only one eye injury because of inattention to this rule and fortunately it was not a serious one.

SUMMARY

1. Data concerning the number and kinds of athletic injury which occurred at a boys' boarding school over a period of seven consecutive school years are presented together with summaries of the number of hospital admissions and hospital days spent because of injuries which developed in various sports.

2. There was little difference in the average number of injuries per participant in soccer, basketball, hockey, baseball, wrestling, and lacrosse; averages ranged from 0.05 to 0.09 injuries per participant per year. In eleven-man football the incidence of injuries was about eight times as great as those in other games, but six-man football averaged only about one and one-half as many injuries per player as did hockey or lacrosse.

3. Similar differences were noted between the various sports in regard to number of "major" injuries, number of hospital admissions, and number of hospital days.

4. Tables showing the incidence of various kinds of injury in each of the various sports are given.

5. Methods of attempting to prevent athletic injuries and the types which are most common are discussed with particular attention to those of the knee, head, and ankle.

TABLE I

Average Number of Participants	*Approximate Duration in Weeks*		*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1947*	*Total Number of Injuries*	*Average Number of Injuries per Year*	*Average Number of Injuries per Participant per Year*
172	7	Soccer	8	7	9	7	6	15	13	....	65	9.29	0.05
48	8	Football Varsity	48	32	29	15	33	16	26	....	199	28.43	0.59
82	8	Football Junior Varsity	64	33	24	11	37	29	33	....	231	33.00	0.40
145	7	Football 6-Man	45	22	18	6	12	13	14	....	130	18.57	0.13
70	8	Hockey	*	*	2	11	5	2	5	8	33	5.50	0.08
90	12	Wrestling	*	*	3	0	3	5	10	18	39	6.50	0.07
100	12	Basketball	*	*	5	4	0	5	4	10	28	4.67	0.05
100	10	Baseball	*	6	11	8	7	2	17	10	61	8.71	0.09
100	9	Lacrosse	*	4	2	4	6	4	11	19	50	7.14	0.07
175	28	Track	*	4	2	6	2	6	6	7	33	4.71	0.03
		Total									869		

This table shows the total number of injuries which required either admission to the school's hospital or attention in its out-patient department for each of several sports during the years 1940 through 1947. The approximate duration of each sport's season, the average number of participants in each sport and the average number of injuries per participant are also given. The figures given for the number of participants in hockey, and in the sports listed below it, are not only average but also approximate; it is obvious, however, that a considerable variation in these figures would produce only slight differences in the average number of injuries per participant.

* Data not available.

TABLE II

Average Number of Participants	*Approximate Duration in Weeks*		*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1947*	*Total Number of Major Injuries*	*Average Number of Major Injuries per Year*	*Average Number of Major Injuries per Participant per Year*
172	7	Soccer	*	*	0	2	1	2	1	—	6	1.20	.007
48	8	Football Varsity	14	11	17	9	5	2	6	—	64	9.14	.19
82	8	Football Junior Varsity	23	11	16	6	7	5	7	—	75	10.70	.13
145	7	Football 6-Man	11	4	8	2	4	4	3	—	36	5.10	.035
70	8	Hockey	*	*	1	2	0	0	1	1	5	.83	.012
90	12	Wrestling	*	*	0	0	1	0	1	4	6	1.00	.011
100	12	Basketball	*	*	2	0	0	1	0	0	3	.50	.005
100	10	Baseball	*	1	4	0	1	1	3	3	13	1.86	.019
100	9	Lacrosse	*	0	1	0	1	1	0	3	6	.85	.008
175	28	Track	*	1	0	1	1	1	1	1	6	.85	.004
		Total									220		

This table shows the total number of "major" injuries occurring in each sport over the years 1940 through 1947. A "major" injury is arbitrarily defined in this report as one which caused an absence of ten or more days from athletics; all other injuries are classified as minor. The figures given for the number of participants in hockey, and in the sports listed below it, are not only average but also approximate; it is obvious, however, that a considerable variation in these figures would produce only slight differences in the average number of injuries per participant.

* Data not available.

TABLE III

Average Number of Participants	*Approximate Duration in Weeks*		*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1947*	*Total Number of Admissions*	*Average Number of Admissions per Year*	*Average Number of Admissions per Participant per Year*
172	7	Soccer	0	6	4	1	2	8	3	—	24	3.4	.02
48	8	Football Varsity	48	20	11	12	10	11	5	—	117	16.9	.35
82	8	Football Junior Varsity	65	17	12	6	18	19	8	—	145	20.7	.25
145	7	Football 6-Man	44	15	10	2	4	7	2	—	84	12.0	.08
70	8	Hockey	*	*	1	3	0	0	1	3	8	1.3	.019
90	12	Wrestling	*	*	0	1	2	4	5	5	17	2.8	.031
100	12	Basketball	*	*	1	2	0	1	2	1	7	1.2	.012
100	10	Baseball	*	1	8	0	1	1	5	1	17	2.4	.024
100	9	Lacrosse	*	2	2	1	1	2	3	5	16	2.3	.023
175	28	Track	*	4	1	1	1	0	1	2	10	1.4	.008
		Total									445		

This table shows the total number of hospital admissions occurring in each sport over the years 1940 through 1947. All types of injuries both major and minor are included. The figures given for the number of participants in hockey, and in the sports listed below it, are not only average but also approximate.

* Data not available.

TABLE IV

Average Number of Participants	*Approximate Duration in Weeks*		*1940*	*1941*	*1942*	*1943*	*1944*	*1945*	*1946*	*1947*	*Total Number of Days*	*Average Number of Days per Year*	*Average Number of Days per Participant per Year*
172	7	Soccer	*	17	7	1	2	10	9	—	46	7.7	.04
48	8	Football Varsity	43	115	44	55	18	18	15	—	308	44.0	.91
82	8	Football Junior Varsity	63	42	56	11	61	51	34	—	318	45.4	.55
145	7	Football 6-Man	42	18	38	5	7	18	11	—	139	19.8	.14
70	8	Hockey	*	*	2	20	0	0	3	11	36	6.0	.08
90	12	Wrestling	*	*	0	2	6	7	11	8	34	5.7	.06
100	12	Basketball	*	*	8	4	0	1	3	1	17	2.8	.03
100	10	Baseball	*	8	15	0	4	5	7	3	42	6.0	.06
100	9	Lacrosse	*	9	3	1	56**	6	4	21	100	14.3	.14
175	28	Track	*	4	3	1	15	0	24	6	53	7.6	.04
		Total									1093		

This table shows the total number of hospital days spent because of major or minor injuries for each sport during the years 1940 through 1947. The figures given for the number of participants in hockey, and in the sports listed below it, are not only average but also approximate.

* Data not available.

** One injury; fracture of femur.

TABLE V

Injury	*Varsity and Junior Varsity Football*	*Varsity Football*	*Junior Varsity Football*	*6-man Football*	*Soccer*	*Hockey*	*Wrestling*	*Basketball*	*Baseball*	*Lacrosse*	*Track*	*Total*
Fracture:												
Nose	15	3	12	8	2	6	2	0	1	0	0	34
Tooth	3	2	1	0	0	1	0	0	1	1	0	6
Jaw	1	1	0	0	0	1	0	0	0	0	0	2
Rib	2	1	1	1	0	1	0	0	0	0	0	4
Spine, transverse process	1	0	1	0	0	0	0	0	0	1	0	2
Femur	0	0	0	0	0	0	0	0	0	1	0	1
Femur, lesser trochanter	0	0	0	0	0	0	0	0	0	0	1	1
Ilium, anterior superior spine	0	0	0	0	0	0	0	0	0	0	1	1
Ischium, tuberosity	1	1	0	0	0	0	0	0	0	0	0	1
Clavicle	2	1	1	2	0	0	0	0	0	0	0	4
Radius and Ulna	1	0	1	2	0	0	0	0	0	0	1	4
Humerus, epicondyle	1	1	0	0	0	0	0	0	0	0	0	1
Radius, styloid	0	0	0	1	0	0	0	0	1	0	0	2
Tibia and fibula	2	0	2	1	0	0	0	1	0	0	0	4
Patella	0	0	0	0	0	0	0	0	1	0	0	1
Fibula	2	1	1	0	0	0	0	0	0	0	0	2
Tibia	1	0	1	1	1	0	0	0	1	0	0	4

This table shows a summary of the athletic injuries, both major and minor, which were reported to the school hospital or its out-patient department during the school years 1941 through 1947 and also in the fall of 1940. Data on the types of injury which occurred in soccer in 1940 and 1941 are not available so the total in this table shows fifteen less cases than does Table I.

TABLE VI

Injury	*Varsity and Junior Varsity Football*	*Varsity Football*	*Junior Varsity Football*	*6-man Football*	*Soccer*	*Hockey*	*Wrestling*	*Basketball*	*Baseball*	*Lacrosse*	*Track*	*Total*
Fracture:												
Nose	1	0	1	2	1	0	0	0	1	0	0	5
Jaw	1	1	0	0	0	1	0	0	0	0	0	2
Rib	2	1	1	1	0	1	0	0	0	0	0	4
Spine, transverse process	1	0	1	0	0	0	0	0	0	1	0	2
Femur	0	0	0	0	0	0	0	0	0	1	0	1
Femur, lesser trochanter	0	0	0	0	0	0	0	0	0	0	1	1
Ilium, anterior superior spine	0	0	0	0	0	0	0	0	0	0	1	1
Ischium, tuberosity	1	1	0	0	0	0	0	0	0	0	0	1
Clavicle	2	1	1	2	0	0	0	0	0	0	0	4
Radius and Ulna	1	0	1	2	0	0	0	0	0	0	1	4
Radius, styloid process	0	0	0	1	0	0	0	0	1	0	0	2
Tibia and Fibula	2	0	2	1	0	0	0	1	0	0	0	4
Patella	0	0	0	0	0	0	0	0	1	0	0	1
Fibula	2	1	1	0	0	0	0	0	0	0	0	2
Tibia	1	0	1	1	1	0	0	0	1	0	0	4
Ankle	1	0	1	0	0	0	1	0	2	0	0	4
Foot	2	2	0	1	0	0	1	1	0	0	0	5
Toe	2	0	2	0	0	0	0	0	0	0	0	2
Metacarpals	5	1	4	5	0	0	0	0	1	0	0	11

This table shows a summary of "major" athletic injuries, which were reported to the school hospital during the years 1941 through 1947 and also in the fall of 1940.

Injury	*Varsity and Junior Varsity Foot-ball*	*Varsity Foot-ball*	*Junior Varsity Foot-ball*	*6-man Foot-ball*	*Soccer*	*Hockey*	*Wrest-ling*	*Basket-ball*	*Base-ball*	*La-crosse*	*Track*	*Total*
Contusion:												
Trigeminal nerve	1	1	0	0	0	0	0	0	0	0	0	1
Chest	0	0	0	0	0	0	2	0	0	3	0	5
Kidney	3	2	1	0	0	0	0	0	0	0	0	3
Testes	0	0	0	0	1	0	0	0	0	0	0	1
Arm	0	0	0	0	0	0	3	0	2	5	0	10
Quadriceps	19	8	11	7	10	0	0	0	0	9	1	46
Knee	21	10	11	8	3	0	2	3	2	0	2	41
Gastrocnemius	2	1	1	0	2	0	0	0	0	0	0	4
Miscellaneous	71	44	27	15	0	0	0	0	1	0	3	90
Laceration:												
Face	0	0	0	0	5	9	1	2	1	1	0	19
Scalp	0	0	0	0	1	5	1	1	0	0	0	8
Miscellaneous	11	6	5	3	0	1	0	0	3	0	4	22
Concussion:	70	30	40	22	4	2	11	0	3	4	0	116
Wry Neck	0	0	0	1	0	0	2	0	0	1	0	4
Hemorrhage, Vocal cords	0	0	0	0	0	0	1	0	0	1	0	2
Rupture, Ear drum	0	0	0	0	0	0	1	0	1	0	0	2
Hemorrhage, Anterior Chamber, eye	0	0	0	0	0	0	0	0	1	0	0	1
Muscle Strains, Miscellaneous	21	11	10	1	0	0	1	0	0	0	5	28
Tear, acromio clavicular ligament	7	3	4	2	0	0	0	0	0	0	0	9
Foreign body, eye	0	0	0	0	1	0	0	0	0	0	0	1
Total	430	199	231	130	50	33	39	28	61	49	34	854

Injury	*Varsity and Junior Varsity Football*	*Varsity Football*	*Junior Varsity Football*	*6-man Football*	*Soccer*	*Hockey*	*Wrestling*	*Basketball*	*Baseball*	*Lacrosse*	*Track*	*Total*
Fracture:												
Ankle	1	0	1	0	0	0	1	0	2	0	0	4
Foot	3	2	1	1	0	0	1	1	1	0	0	7
Toe	3	0	3	1	2	0	0	0	0	0	0	6
Metacarpals	5	1	4	4	0	0	0	0	1	0	0	10
Finger	15	6	9	10	2	1	1	1	15	1	0	46
Dislocation:												
Humerus	7	3	4	1	0	0	0	0	1	0	0	9
Humerus (recurrent)	1	0	1	1	0	0	0	0	0	0	0	2
Elbow	1	0	1	0	0	0	1	0	0	0	1	3
Finger	2	1	1	1	0	1	0	0	1	0	0	5
Patella	0	0	0	1	0	1	0	0	0	0	0	2
Sprain:												
Ankle	46	28	18	17	13	1	1	15	6	10	10	119
Knee, ligament tear	62	25	37	15	2	0	2	1	3	3	2	90
Knee, semi-lunar cartilage injury	8	3	5	0	0	0	0	0	0	0	0	8
Elbow	2	1	1	0	0	0	0	0	0	0	0	2
Shoulder	0	0	0	0	0	0	1	0	1	0	2	4
Wrist	4	1	3	2	0	2	1	0	0	2	1	12
Finger	9	0	9	0	1	1	1	3	7	2	0	24
Contusion:												
Eye	3	1	2	1	0	0	2	0	1	2	0	9
Nose	0	0	0	0	0	0	0	0	3	2	0	5

Injury	*Varsity and Junior Varsity Football*	*Varsity Football*	*Junior Varsity Football*	*6-man Football*	*Soccer*	*Hockey*	*Wrestling*	*Basketball*	*Baseball*	*Lacrosse*	*Track*	*Total*
Dislocation:												
Humerus	7	3	4	1	0	0	0	0	1	0	0	9
Elbow	1	0	1	0	0	0	1	0	0	0	1	3
Finger	0	0	0	1	0	1	0	0	1	0	0	3
Sprain:												
Ankle	15	11	4	0	2	0	0	0	0	1	0	18
Knee, ligament tear	34	17	17	9	1	0	2	1	2	2	2	53
Knee, semilunar cartilage	8	3	5	0	0	0	0	0	0	0	0	8
Elbow	1	1	0	0	0	0	0	0	0	0	0	1
Contusion:												
Eye	1	1	0	0	0	0	0	0	0	0	0	1
Trigeminal nerve	1	1	0	0	0	0	0	0	0	0	0	1
Kidney	3	2	1	0	0	0	0	0	0	0	0	3
Testes	0	0	0	0	1	0	0	0	0	0	0	1
Quadriceps	9	3	6	1	0	0	0	0	0	0	0	10
Knee	3	1	2	5	0	0	0	0	0	0	0	8
Gastrocnemius	2	1	1	0	0	0	0	0	0	0	0	2
Laceration:												
Hand	1	1	0	1	0	0	0	0	0	0	0	2
Thigh	0	0	0	0	0	1	0	0	0	0	0	1
Concussion	21	8	13	2	0	1	0	0	1	0	0	25
Hemorrhage, Vocal cords	0	0	0	0	0	0	0	0	0	1	0	1
Rupture, ear drum	0	0	0	0	0	0	1	0	0	0	0	1
Hemorrhage, anterior chamber, eye	0	0	0	0	0	0	0	0	1	0	0	1
Muscle Strain, deltoid	2	1	1	0	0	0	0	0	0	0	0	2
Tear, acromio-clavicular ligament	6	2	4	0	0	0	0	0	0	0	0	6
Total	139	64	75	36	6	5	6	3	13	6	6	220

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Postwar Interests in Physical Education at the Ohio State University

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DURING the 1946-47 academic year, the Ohio State University had what was believed to be one of the largest men's service class physical education programs of any university in the United States, with 5,462 men under instruction.

The whole question of the physical education activity interests of men college students, which has been an educational problem for many years, arose again and it was decided to find out not only what these interests and needs were, but also to survey ideas, attitudes, and feelings in regard to certain phases of the physical education program at the university.

This group of college men in the service program was essentially a different group from the men in physical education before the war. A majority were veterans (810 of 1,040 in this random study), they were older, more mature, and had had a wider range of experiences in sports and physical education than the men before the war. The study attempted, therefore, not only to find out student interests and needs, but also to compare the results of this study with similar studies conducted before the war.

A questionnaire was developed and administered to 1,100 of the 5,000 men in the program. Ten hundred and forty were returned. The following data were compiled from these returns.

RESULTS OF THE STUDY

The first question was designed to learn those physical education activities in which the men in the program (1) were most interested, (2) had considerable interest, and (3) had no interest. Sixty-two of the most common physical education activities were listed.

Question 1: There were three parts to the first question.

A. Mark with a number one (1) those physical education activities in which you are most interested; that is, would most like to learn or participate in. Do not mark more than three.

B. Mark with a number two (2) those physical education activities in which you have considerable interest and yet less than the top three. Do not mark more than six.

C. Mark with a number three (3) those physical education activities in which you have absolutely no interest and have no desire to learn or participate. Do not mark more than six.

TABLE I

FIRST TEN FIRST-CHOICE PREFERENCES IN PERCENT OF RESPONSES

First ten first-choice preferences in percent of the 3,527 responses		First ten second-choice preferences in percent of the 5,785 responses		First ten least-choice preferences in percent of the 4,009 responses	
1—Bskball.	13 percent	1—Bowling	5 percent	1—Marching	8 percent
2—Golf	10 percent	2—Swimming	5 percent	2—Tap dance	5 percent
3—Swimming	9 percent	3—Golf	4 percent	3—Calisthenics	4 percent
4—Tennis	8 percent	4—Football	4 percent	4—Walking	4 percent
5—Football	7 percent	5—Softball	3 percent	5—Fencing	3 percent
6—Baseball	6 percent	6—Tennis	3 percent	6—Wrestling	3 percent
7—Bowling	5 percent	7—Bskball.	3 percent	7—Sq. Dancg.	3 percent
8—Softball	3 percent	8—Pstl. Shtg.	3 percent	8—Cross Ctry.	2 percent
9—Pstl. Shtg.	3 percent	9—Baseball	3 percent	9—Boxing	2 percent
10—Boxing	2 percent	10—Ice Sktg.	3 percent	10—Wgt. Lftg.	2 percent

First choice: Basketball, receiving 13 percent of all first-place choices shows the great interest in this sport. Other team games which ranked high on the list in popularity were football, (5th), baseball (6th), and softball (8th).

The choice of golf, swimming, and tennis, following basketball, indicates a strong desire on the part of the college men to learn individual sports with carry-over value. The place of bowling reflects the nationwide increase in interest in bowling, and the great number of votes for pistol shooting and boxing was probably due to the fact that many of the men were exposed to these two activities in military service.

Second choice: Bowling ranked first among second-choice activities again following the nationwide trend of a great increase in interest in this sport.

Swimming, golf, and tennis ranked high as second-choice activities which again shows the great interest in these individual sports with carry-over value.

Football (4th), softball (5th), basketball (6th), and baseball (9th), reiterate the interest in these national sports by Ohio State University students.

Third choice: Marching appears to be the least desirable physical education activity. Forty-five percent of the eight hundred and ten (810) veterans and thirty-one percent of the two hundred and thirty non-veterans who answered this question indicated a dislike for marching. Calisthenics was also low on the popularity list at Ohio

State University. Both marching and calisthenics are formal physical education activities in which the individual loses his identity.

Question 2: "In what activities in which you have had instruction at Ohio State University would you desire additional instruction?"

Of the 859 replies to this question, 24.3 percent indicated a desire for more swimming instruction. Individual sports with carry-over value, swimming, tennis, golf, boxing, handball, and fencing ranked first, second, fourth, fifth, sixth and tenth, respectively, among the first ten.

With only three team sports chosen among the first ten, basketball, volleyball, and touch football, it can be assumed that the students in the physical education program desire to learn more about individual sports with carry-over value than about team games.

Question 3: "In what activities in which you have received no instruction would you desire instruction?"

Golf is the activity in which the most students in the program desired instruction and in which they had received none. Over 17 percent of those answering the question requested golf. Golf was followed by tennis (10 percent), bowling (7 percent), swimming (5 percent), and diving (4 percent). This would again indicate a desire of college students to learn individual sports with carry-over value.

Basketball and baseball which ranked sixth and ninth respectively were the only team sports in the first ten activities listed.

Question 4: "Which of the following groups of physical education activities would you prefer? (a) gymnastics, calisthenics, heavy apparatus, marching; (b) games and sports; (c) a combination of both."

Of the 1,025 men who answered this question, 72.6 percent preferred games and sports, 25.9 percent preferred a combination of both, 1.5 percent preferred gymnastics, calisthenics, heavy apparatus, and marching.

Question 5: "What is your feeling in regard to physical education requirements on a yearly basis at Ohio State?

One year	Required	Elective
Additional one year	Required	Elective
Additional two years	Required	Elective
Additional three years	Required	Elective

Results showed that 27 percent preferred a year of required physical education plus the right to elect an additional year, 21 percent preferred one year required and also the privilege of electing three more years, 21 percent felt that the present requirement of

one year was the proper amount, 8 percent felt no physical education should be required but elective for only one year.

These results indicate that if physical education were put on a required-elective basis at Ohio State University, rather than required only, students would be interested in more physical education.

Question 6: "If you are a veteran, do you prefer the type of physical education program offered at Ohio State in contrast to physical training offered you in the services?"

An overwhelming majority of the veterans (94 percent) preferred the program at Ohio State. In giving reasons for their answers, 35 percent wrote in that they were permitted here to choose the activity in which they were to participate. Sixteen percent stated they preferred the variety of activities offered here. Forty-three percent of the respondents stated they disliked service physical training because of calisthenics. Fourteen percent indicated they had little or no physical training in service.

Question 7: "If you are not a veteran, do you prefer (a) the type of physical education program offered at Ohio State in contrast to the physical education program offered you in high school? (b) the type of physical training offered you in high school in contrast to the physical education program offered you at Ohio State."

Ninety-two (92 percent) percent preferred the program at Ohio State University. The main reasons given for preferring the Ohio State program were (a) variety of activities offered (35 percent), and (b) individual instruction (23 percent).

Many other students indicated they liked the Ohio State program best, but it was actually because they disliked their high school program. Some of the reasons given for disliking their high school program were:

1. "I accomplished nothing in physical education in high school."
2. "No choice of activities."
3. "Few facilities, wasted time, nothing but calisthenics."
4. "Program just basketball and football."

Question 8: "Do you feel the activities offered in the physical education program at Ohio State University in sports skills and knowledge have carryover value; that is, are they something which you can use in later life?"

The Physical Education Department at Ohio State offers a wide variety of activities in its program with special emphasis upon such individual sports as swimming, golf, fencing, tennis, and handball. Ninety-four percent of those answering this question felt that these activities did have carry-over value.

Question 9: "Would you be interested in a program of coedu-

cational physical education in such activities as tennis, golf, badminton, dancing, and swimming?"

Eighty-five per cent of the replies were in favor of such a program. It would, therefore, seem that more emphasis might be placed upon coeducational physical education at the college level. Besides the physical benefits to be derived from such a program there are the added social values that men and women students gain from participating in sports activities together.

Question 10: "What physical education and recreation facilities would you like to see developed at Ohio State University which it does not now have?"

There was a wide variety of answers to this question but bowling facilities were requested most often. Twenty-one percent of the 468 students answering this question requested bowling. Following bowling, the men wanted horseback riding, 8 percent; ice skating, 8 percent; boating, 6 percent; social dancing, 5 percent; polo, 3 percent; ice hockey, 3 percent.

The bowling interest at Ohio State seems to parallel the growing nationwide interest in the sport.

Question 11: "What comments, of any nature, do you have regarding your physical education program at Ohio State?"

The 517 answers to this question were divided into three groups: those favorable to Ohio State, those unfavorable, the miscellaneous. Thirty-five percent of all answers specifically stated they thought the Ohio State University program was a good one. Included in these answers were these comments: "Good program," "Good instruction," "Plenty of variety," "Well balanced," "Beneficial," "Carryover value," "High standards," and "Good facilities."

Some comments unfavorable to the program were: "Classes too crowded," "Unable to get activity I desire," "Periods too short," "Need for individual instruction," "Not enough physical education," "Better system of grading needed," and "More play, less rules, and more facilities."

Question 12 (For married men only): If the physical education department were to provide instruction and facilities to teach you and your wife such activities as tennis, golf, badminton, dancing, and swimming, would you be interested?

Of the 164 replies, 91 per cent were in the affirmative. This question was included because of the large number of married veterans at Ohio State University. With 91 percent of these married veterans desiring physical education activities with their wives it would seem that a program of this type would be most desirable.

COMPARISONS WITH OTHER STUDIES

The study most closely corresponding with this study was one conducted at Pennsylvania State College by Davis.[1] This was concerned with freshmen interests in physical education activities in 1931 and 1932. The most significant comparisons concerned student interests in various activities at Penn State in 1931 and Ohio State in 1946. The implications in comparing the two are:

1. Basketball was the most popular sport with freshmen at Pennsylvania State College in 1931 and at Ohio State University in 1946. This game seems to have the elements of speed, skill, strategy, and competition all of which appeal to American youth.

2. Interests have changed very little in the past 16 years. The following sports were favorably chosen in both surveys: basketball, softball, tennis, boxing, and golf.

3. Swimming, a popular sport at Ohio State University, was not mentioned by Pennsylvania State College students as they had no swimming facilities when the study was made and they ranked only those activities offered specifically in their program.

4. The activities mentioned in 1946 at Ohio State that were not mentioned in 1931 at Pennsylvania State College as being popular were swimming, football, baseball, bowling, and pistol shooting.

5. Similar physical education activities were disliked by both groups and included heavy apparatus, calisthenics, marching cross country, boxing, fencing, and wrestling. No competitive team games were mentioned by either group.

COMPARISON WITH ACTIVITIES OF COMMITTEE ON CURRICULUM RESEARCH

A comparison of the first ten activities chosen by the Committee on Curriculum Research as providing "all-round contributions" to college men[2] and the first ten first-choice activities of the students in the physical education program at Ohio State reveals that six of the first ten activities listed as providing all-round contribution are indicated in the first ten first-choice activities of the Ohio State men. They are swimming, tennis, touch football, basketball, baseball, and softball.

COMPARISONS WITH CHOICES OF BUSINESS AND PROFESSIONAL MEN

It was revealed, in comparing activities participated in by busi-

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1Elwood C. Davis. "A Study of the Interests of the Pennsylvania State College Freshmen in Certain Formal and Natural Physical Activities," *Research Quarterly*, 8:3 (October, 1937), p. 36.

2William R. LaPorte. "Seventh Annual Report of the Committee on Curriculum Research," *Research Quarterly*, 6:2 (May, 1935), p. 3.

ness and professional men, as found in a study by Scott in 1927,[3] with Ohio State students, that the business and professional men participate in less strenuous activities than college men, although common to both groups were swimming, golf, tennis, and bowling. It was also found that college men like the more vigorous activities such as basketball, baseball, and football, while business and professional men prefer less active sports such as fishing, hunting, gardening, and calisthenics.

This study makes no claim for reliability or objectivity; however, it represents a way of laying foundation material upon which administration and curriculum policies may be based, and also represents an effort to arrive at the truth regarding certain physical education matters which are vital issues in this postwar period.

[3]Harry A. Scott. "Physical Recreation and Exercises for Business Men." *The Nation's Health*, 9:6 (June, 1927).

The Relationship Between Pre-Exercise and Post-Exercise Pulse Rate

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INTRODUCTION

SOME emphasis has been placed upon the value of pre-exercise heart rate in various tests designed to determine physical fitness by cardiac response to measured amounts of exercise. This study was done in an attempt to determine the relationship between the pre-exercise pulse rate and the pulse rate following prescribed amounts of exercise in male university students presumed to be in good physical condition. Students who were currently engaged in intercollegiate athletics or participated daily in activity courses for physical education majors were used as subjects.

In order to find the relationship between the resting pulse rate and the increase in rate following exercise, Tuttle and Salit (4) conducted a study in which men and women university students varying in physical condition from poor to good were used as subjects. Each subject was tested once each week over a four-week period. Exercise was performed on a bicycle ergometer which was peddled at the rate of 60 revolutions per minute for one minute and at the maximum rate for a period of two minutes. In addition they used the data on 547 male university students who had performed the step-up exercise at the rate of 40 steps per minute on a 13-inch step for a period of one minute. These investigators also used Jokl's (3) data on 32 South African recruits. Jokl secured the resting heart rate and the post-exercise heart rate before, and at six-week intervals, during a 24-week physical training program. The subjects in the study conducted by Jokl participated in exercise which consisted in 40 knee bends for a period of one minute.

From their data Tuttle and Salit drew the following conclusions:

1. The size and sign of the coefficient of correlation between the resting heart rate and the increase in rate due to exercise depends upon the strenuousness of exercise.

2. A group of persons whose physical condition varies from poor to good, during mild or moderate exercise will give either a small negative or small positive coefficient of correlation.

3. Strenuous exercise results in a high negative coefficient of correlation between the resting heart rate and the increase due to exercise. This is due

to the fact that every person approaches the maximum rate, so that those with the lowest resting rate experience the greatest increase, whereas those with the higher rates experience less increase.

Unpublished data collected by Beecher (1) show small positive coefficients of correlation between the before-exercise and post-exercise pulse rates. Beecher's subjects were freshmen college women. The step-up exercise was performed on a 16-inch step at the rate of 24 steps per minute for a 60-second period and for a 30-second period. The coefficient of correlation between the resting pulse rate and the pulse rate taken for 30 seconds immediately after 30 seconds of exercise was +0.137. The coefficient of correlation between the before-exercise rate and the rate following one minute of exercise was +0.120.

PROCEDURE

Fifty male university students majoring in physical education and enrolled in courses demanding regular physical activity were used as subjects. Each subject was required to engage in the step-up exercise on a 16-inch bench during three different periods. For convenience these periods will be referred to as period 1, period 2, and period 3. Since period 3 was divided into four bouts of exercise, these will be referred to as 3a, b, c, and d. Exercise in period 1, was for 30 seconds in duration in which a cadence of 18 steps per minute was used. After the subject had rested for 15 minutes he engaged in the second period of exercise (period 2) which was 60 seconds in duration. A cadence of 18 steps per minute was also used during this period. The following day each subject participated in four bouts of exercise for 60 seconds each at a cadence of 36 steps per minute with only sufficient time between bouts to allow the pulse to be taken for 30 seconds (periods 3a, b, c, and d).

The before-exercise pulse rate was taken for 30 seconds with the subject in a sitting position prior to periods 1, 2, and 3a. The after-exercise pulse rate (with subject in a sitting position) was recorded for 15 and 30 seconds following exercise. As previously mentioned, the elapsed time between periods 3a, b, c, and d, was only long enough to take the pulse rate for 30 seconds.

A stop watch was used to assist in taking the pulse rate and the cadence was set by means of an electric metronome. Since the heavier subjects were required to perform a greater amount of work when measured in foot-pounds, it was considered advisable to secure information relative to the relationship between weight and the pulse rate after exercise. For this reason the weight of each subject was recorded prior to testing.

All data were collected by the same tester. The step-up exercise was performed in the manner described by Elbel and Green (2).

The pulse rates were recorded for 30 seconds prior to exercise

and for 15 and 30 seconds following exercise. These figures were then converted into rates per minute. The means and standard deviations for each period were computed. Coefficients of correlation were determined between the before-exercise pulse rates and the increase in pulse rates following exercise. Coefficients of correlation between the increase in pulse rate after exercise and bodily weights were also computed. The critical ratio of the difference between the means for periods 3a, b, c, and d, were calculated.

In order to determine the relationship between the pre-exercise pulse rates and the after-exercise rate, the data for each type of exercise were placed in three different groups in accordance with the pre-exercise rates. The mean rise in pulse rate was then computed for each group (Table IV).*

RESULTS

In computing the coefficients of correlation between bodily weights and increase in pulse rate recorded for 15 and 30 seconds following exercise, it was found that the range was from —.004 to +.162 (Table I). None of these correlations was found to be significant. In view of these insignificant correlations it was concluded that the matter of bodily weight is not related to the amount of increase in pulse rate resulting from participation in prescribed amounts of exercise.

The coefficients of correlation between the before-exercise pulse rates and those recorded for 15 seconds and 30 seconds following the different periods of exercise are shown in Table II, along with the respective means and standard deviations. The coefficients of correlation between the pre-exercise pulse rates and the rise in pulse rate following the mild exercise for periods 1 and 2 were found to be positive but insignificant for both the 15-second and 30-second pulse. With the strenuous exercise in the third period the coefficients of correlation are all negative and were generally found to become increasingly large with each successive bout of exercise. While these coefficients of correlation are generally low, a substantial negative correlation (—.614) is shown between the pre-exercise pulse and the rise for 15 seconds following period 3d.

That the work done during period 3 was strenuous is shown by the fact that the mean increase in pulse rate taken for 15 seconds following the final bout of exercise was 95.99 beats and 87.5 for 30 seconds following exercise. In spite of the period of slightly more than 30 seconds of elapsed time between bouts of exercise, a true difference between the mean increase for each bout was evidenced with the exception of the difference between means for periods 3b and c, for the pulse taken for 30 seconds. In this instance the critical

*Tables will be found at end of article.

ratio of the mean difference was 2.94 which is significant on the one percent level of probability. In all other instances the critical ratio was above three. The obtained differences between means and critical ratios are shown in Table III.

In an attempt to determine whether the pre-exercise pulse rate has a bearing upon the amount of rise in pulse rate during exercise, the pre-exercise pulse rates for all subjects were placed in one of three groupings in accordance with the exercise periods as follows: period 1, 58-68, 70-76, 78-100; period 2, 56-68, 70-76, 78-96; period 3, 54-68, 70-78, 80-100. The differences between mean rise in pulse rate for each group for each period of exercise were then determined. For period 3, only the data for the rise in pulse rate following the bout of exercise 3d were used. The means, mean rise in pulse rate, critical ratios of the difference between means for pulse taken for 15 and 30 seconds following exercise are shown in Table IV. It will be noted that the mean increases in pulse rate for the grouping shown for periods 1 and 2 differ only slightly and the critical ratios of the mean difference are extremely small. However, following the strenuous exercise done during period 3, it is clearly shown that the group with the lowest resting pulse had the greatest rise and the group with the highest pre-exercise rate had the least increase due to exercise.

Following mild or moderate work the rise in pulse rates is about the same within groups regardless of the pre-exercise level. For strenuous exercise the rise was truly higher for those with a low resting pulse than those with a high pre-exercise pulse. In this regard it is interesting that the pre-exercise rate of one subject was 62. The pulse taken for 30 seconds after exercise showed a rise of 106 beats, while another subject showed a resting pulse of 100. The increase for the latter subject was only 68.

DISCUSSION

In spite of the fact that, for the most part, Tuttle and Salit (4) used a different form of exercise and their subjects apparently varied in physical condition much more than those in this study, there are several interesting comparisons that can be made with their data. The moderate exercise done by their subjects (one minute of exercise on bicycle ergometer 60 revolutions per minute) showed a coefficient of correlation of +0.281 for men, —0.285 for women. The moderate exercise in this study which was perhaps less strenuous than that of Tuttle and Salit gave a coefficient of correlation between the pre-exercise pulse rate and the increase due to exercise of +0.019 for the 15-second pulse and —0.048 for the pulse taken for 30 seconds. The records on 547 male college students (Tuttle and Salit) in which the step-up exercise was used at a cadence of 40 steps per minute yielded a coefficient of correlation of +0.203 pre-exercise and post-exercise pulse rates.

In this study the coefficients of correlation between the pre-exercise and the pulse rates following the strenuous exercise were all negative whether the pulse was taken for a period of 15 seconds or a period of 30 seconds following exercise. The step-up exercise used in period 3 for this study was at a cadence of 36 steps per minute on a 16-inch step; Tuttle and Salit used 40 steps per minute on a 13-inch step. In comparing the data for the first minute of strenuous exercise (period 3a) with those of Tuttle and Salit for a similar period it is shown that this study gave small negative correlations (—0.337 and —0.235) while the above-mentioned investigators secured a positive but small coefficient of correlation (+0.203).

It is interesting to note that during period 3 of this study the coefficients of correlation between the resting pulse and the pulse taken for 15 seconds immediately after exercise grow increasingly large. This is not entirely true for the pulse taken for 30 seconds following exercise in that there is a slight difference between the coefficient of correlation for periods 3c and 3d in favor of the former.

It would appear that in healthy adults there is a negative relationship between the pre-exercise pulse rate and the pulse rate following any activity which is sufficiently vigorous to tax the capacity of the circulatory system, whether the individual is in poor, fair, or good physical condition.

SUMMARY AND CONCLUSION

Fifty male university students presumed to be in good physical condition performed the step-up exercises during three different periods of activity as follows:

1. For 30 seconds at a rate of 18 steps per minute.
2. For 60 seconds at a rate of 18 steps per minute.
3. For four 60-second bouts of exercise at the rate of 36 steps per minute.

The data for pre-exercise rates were compared with those for the rates following exercise. Data for increase in pulse rate due to exercise were also correlated with the body weight. It was determined that:

1. The coefficient of correlation between body weight and increased pulse rate due to exercise is insignificant.
2. The coefficients of correlation between the pre-exercise pulse rate and increase due to the step-up exercise done at the rate of 18 steps per minute for periods of 30 and 60 seconds are positive but insignificant.
3. There is a negative correlation between the pre-exercise pulse rate and the increase due to the step-up exercise performed at the rate of 36 steps per minute during four 60-second bouts of exercise.

For the pulse taken for 15 seconds following exercise the coefficient of correlation becomes increasingly greater with each bout of exercise reaching a substantial negative coefficient of correlation (-0.614) following the fourth 60-second bout of exercise. The coefficients of correlations for the pulse taken for 30 seconds do not show the consistent pattern followed by the pulse taken for 15 seconds, although they are all negative.

4. Considering the three groups classified according to pre-exercise pulse rate, it was found that there is not a true difference between the mean pulse increase for groups following mild and moderate exercise. Following strenuous exercise there is a true difference between the mean increase for the group with low and the group with rapid pre-exercise pulse rates (Table IV).

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TABLE I

COEFFICIENT OF CORRELATION BETWEEN BODY WEIGHT AND INCREASE IN PULSE RATE RECORDED FOR 15 AND 30 SECONDS AFTER EXERCISE

	Period I	Period II	Period III	Period IIIa	Period IIIb	Period IIIc	Period IIId
Pulse for 15 seconds	—.028	—.029	+.167	+.011	+.011	—.004	—.013
Pulse for 30 seconds	+.112	+.162	+.113	+.014	+.014	—.085	+.026

To be significant coefficient of correlation must exceed .3541 on .01 level of probability.

TABLE II

MEANS AND STANDARD DEVIATIONS OF PRE-EXERCISE PULSE; MEANS AND STANDARD DEVIATIONS FOR PULSE RECORDED FOR 15 SECONDS AND FOR 30 SECONDS FOLLOWING EXERCISE AND COEFFICIENTS OF CORRELATIONS BETWEEN, BEFORE, AND AFTER EXERCISE

	Mean Pre-Exercise	S D	Mean Increase 15 seconds	S D	Mean Increase 30 seconds	S D	Coefficients of Correlations 15 seconds	30 seconds
Period I	73.7	9.25	28.75	8.20	19.5	8.28	+.029	+.021
Period II	74.0	9.30	36.5	10.55	26.3	8.65	+.019	+.048
Period III	74.6	10.30						
Period IIIa			69.3	11.45	62.7	10.55	—.337	—.235
Period IIIb			77.9	10.50	74.7	9.90	—.342	—.396

Period IIIc	88.0	10.25	80.8	10.85	—.376	—.485
Period IIId	95.99	11.0	87.5	11.30	—.614	—.473

To be significant coefficient of correlation must exceed .3541 on .01 level of probability.

TABLE III

DIFFERENCES BETWEEN MEANS AND CRITICAL RATIOS FOR BOUTS OF EXERCISE IN PERIOD III

Period	*Obt. Dif.*	*Critical Ratio*	*Chances in 100*
	15-second pulse		
3 a—b	— 8.60	3.91*	99.98
3 b—c	—10.10	4.85*	99.99
3 c—d	— 7.99	3.75*	99.97
	30-second pulse		
3 a—b	—12.0	5.88*	99.99
3 b—c	— 6.10	2.94*	99.68
3 c—d	— 6.70	3.03*	99.90

* These figures show that all critical ratios are significant on the percent level of probability.

TABLE IV

MEANS, MEAN RISE IN PULSE RATES, AND CRITICAL RATIOS FOR SUBJECTS GROUPED ACCORDING TO PRE-EXERCISE PULSE RATES

Groups Pre-ex. pulse	*Mean Pre-ex. pulse*	*Mean Rise*	*Critical Ratio*	*Chances in 100*
	Pulse taken for 15 seconds after exercise			
	Period I			
A 58-68	63.88	30.25	(A&B) .677	50.34
B 70-76	73.32	27.50	(B&C) .466	36.16
C 78-100	84.18	29.26	(A&C) .423	32.56
	Period II			
A 56-68	63.56	38.0	(A&B) .233	18.20
B 70-76	72.75	39.0	(B&C) 1.13	74.16
C 78-96	84.40	34.66	(A&C) 1.23	78.14
	Period III			
A 54-68	63.79	105.34*	(A&B) 2.91**	99.64
B 70-78	75.26	94.23*	(B&C) 2.12	96.60
C 80-100	89.88	88.0*	(A&C) 4.59**	99.99
	Pulse taken for 30 seconds after exercise			
	Period I			
A 58-68	63.88	21.82	(A&B) .263	20.52
B 70-76	73.32	20.96	(B&C) .339	26.62
C 78-100	84.18	20.20	(A&C) .658	49.08
	Period II			
A 56-68	63.56	27.50	(A&B) .778	56.46
B 70-76	72.75	25.75	(B&C) .330	25.86
C 78-96	84.40	26.69	(A&C) .464	35.44
	Period III			
A 54-68	63.79	95.16*	(A&B) 2.27	97.68
B 70-78	75.26	87.18*	(B&C) 2.58**	99.02
C 80-100	89.88	79.88*	(A&C) 4.65**	99.99

* Difference between pre-exercise pulse and pulse taken after exercise period IIId.

** Significant at one percent level of probability.

The Validity of Certain Tests of Endurance[1]

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INTRODUCTION

COACHES and trainers seek to improve the endurance of their athletic squads so that the men under their charge can be counted on to maintain an optimum pace throughout the duration of each game or contest. This quality (endurance) is perhaps more properly known as athletic "condition," and it seems to be generally accepted that "condition" is fundamental to peak performance in all athletic endeavor. Track and swimming coaches use the stop watch as an objective measure of their squads' improvement. However, coaches of other athletic activities usually rely on their experience in subjectively evaluating their squad's condition. It would certainly seem worthwhile to investigate the possibilities of objectively measuring such athletic "condition."

REVIEW OF THE LITERATURE

Recognizing that most of our sports involve large amounts of running, earliest attempts at measuring condition used such performance tests as the quarter- and half-mile runs (5). These runs are very exhausting when the performance is "all-out," and it is also recognized that success is dependent on judgment of pace, will power, and probably several other factors in addition to endurance.

In considering the lap times of the participants in swimming races, Cureton (6) observed that the winners always had the smallest drop-off times throughout the race. He then devised the "drop-off index" as a performance test of endurance in swimming. Arguing that superior endurance would be indicated by a runner's ability to maintain his best speed over a long distance, McCloy (12) proposed an "endurance ratio" which is obtained by dividing a person's 220-yard time by his 60-yard time.

Flanagan (8) sought to establish the pulse-ratio test as a measure of endurance in running. As a criterion of endurance he used the index developed by McCloy, 220-yard time divided by 60-yard time. He reportd a correlation of -.52 between the pulse-ratio test and the endurance index criterion for an experimental group of 51

[1]From the Research Laboratory, Department of Physical Education, University of California, Berkeley.

track men and 5 others. A correlation of -.89 was obtained after omission of 9 cases who were "distinctly away from the regression line." On this basis, he showed a high correlation between the physical efficiency rating as measured by the pulse-ratio test and endurance in sprint running. He also concluded that the pulse-ratio test is a reliable criterion of endurance.

Henry and Kleeberger (10) did further analysis of the relationships between the pulse-ratio test and the endurance index (220/60). They obtained a correlation of -.50 between weight-equated pulse-ratio scores and the index, which confirms the correlation obtained by Flanagan with his unselected data. However, Henry and Kleeberger felt that Flanagan's correlation of -.89 with his selected group was of doubtful significance. The authors also showed a partial correlation of -.46 between the pulse-ratio test and endurance (220-yard time), when the influence of speed (60-yard time) was held constant. This statistical procedure was developed from a consideration of theoretical and experimental evidence tending to indicate that the ratio index as a measure of endurance is unsound. It was indicated that the influence of the speed factor is not removed with such an index.

Since, according to Henry and Kleeberger, endurance must be among the residual factors which keep 60- and 220-yard times from correlating perfectly, the coefficient of alienation (k) offers a measure of the degree to which they may be theoretically separable.

Hodgson and her co-workers (11), in a recent study with women subjects, reported that speed and endurance are perhaps inseparable; the anatomical, physiological, and psychological qualities of an individual which make a high degree of speed possible may very conceivably be the same ones that lead to endurance. The report presents a number of intercorrelations among physiological and performance measures of "exercise tolerance." Ratio and drop-off indices of endurance showed smaller correlations with the physiological criterion than time scores in either of the runs. It was stated, however, that the duration of such a run as the 220-yard run (approximately 35 seconds) "makes the use of any scores derived from it of doubtful value in assessing the runner's tolerance for exercise of an endurance nature" (11). A maximal step test and the Brouha step test had correlations of .74 and .64 respectively with the physiological criterion. Maximal steps also correlated very well with all the running tests except the 50-yard dash. However, the Brouha test correlated rather low with the running tests (below .05). Two endurance indices using the 200-yard and 50-yard data, but arbitrarily adapted to allow for differences in speed, were developed. Their correlations with the other items are of the same magnitude as those

of the 200-yard run. High correlations with the 50-yard dash also indicate a predominance of the speed factor in such scores.

Brouha (2) and others have used the step test to follow condidition changes in athletic squads. One hundred and twenty-five college athletes, not all of them in competing condition, had a mean index score of 93.* In a separate study, crewmen and cross-country runners were studied before, during, and after their training periods. The mean index increased from 87 to 103 for 22 oarsmen, and from 86 to 97 for the runners.

Taylor (14) has used his maximal pack test to follow the training gains in a special physical education class devoted to heavy physical *training*. A group of 10 college men tested before and after the training regime had a mean training gain of 75 seconds. Data were also presented on the Johnson-Brouha pack test, a standardized stepping exercise in which the duration of work is limited to five minutes. Taylor concluded that the test is valid when the subject finds the work maximal, but of very limited value when submaximal. Two-thirds of Taylor's subjects found the work submaximal, indicating the test is weakest where it is used the most.

An extensive study of muscular endurance events common to physical fitness work was published in 1945 by Cureton (7) and co-workers. Included was a factor analysis of 28 motor endurance tests of the type used in the physical conditioning and testing programs in the military services. Tests of endurance in running included in the study were the mile run, 1000-yard run, 300-yard shuttle run, 100-yard run, and a drop-off index (1000-yard time minus 10 times the 100-yard time). Test scores on each test were validated against a composite standard score criterion using all 28 items. The mile run ranked first with a validity coefficient of .708, with the other running items ranking from medium to poor among the 28 tests. The drop-off index correlated .787 with the 1000-yard run, .654 with the mile run, .638 with the 100-yard run, and .541 with the 300-yard shuttle run. The drop-off index, developed by Cureton as a criterion of running endurance in 1942 at the University of Illinois, was thought by him to be theoretically the best measure of endurance conceivable. In a semester of training, the improvement was 5 percent of the standard score scale. The step test had low correlations with all the running tests, the largest being .310 with the mile run. However, the step test showed a mean gain of 11 percent over the conditioning period.

In an unpublished study (4), Cozens has suggested a test designed to measure endurance in running without producing undue

*Any score above 90 is considered to indicate "excellent" physical efficiency.

fatigue. In establishing the criterion, groups of runners were timed on runs up to 300 yards in length. His study showed that "the point of greatest 'fade' lies somewhere between 220 and 300 yards," indicating that a 300-yard run is of sufficient length to show that endurance is operating. In order to establish a test of endurance which would not produce undue fatigue, Cozens developed a regression equation to predict 300-yard time from the times on runs of 150 yards and 75 yards, plus another element obtained from these times. This combination had a multiple R = .955 with the 300-yard time and had a standard error of estimate of .835 seconds. The records of 13 athletes in training showed actual 300-yard times which were faster than those predicted for them on the basis of the regression equation. Cozens suggested that coaches might determine the condition of squad members by comparing actual 300-yard times with predicted times. Since the regression equation was computed for untrained men, the implication was that athletes in training should run faster than the time predicted for them. The use of straight predicted time to indicate change in physical condition of an athletic team was also suggested.

It should be noted that little work has been reported on the measurement of condition of athletic squads other than in track. The sustained running in most of our sports activities leads first to our considering the tests for measuring endurance in running. The Taylor and Brouha tests also offer possibilities in that the exercises used are quite severe and of sufficient duration to bring into play the physiological mechanisms associated with endurance. These tests, like the long endurance runs, are rather difficult to administer and are very exhausting. Theoretically, all endurance runs may be attacked on the premise that they are measuring running skill, judgment of pace, and will power, in addition to endurance. The several "endurance" indices fall down in their attempt to get at the endurance factor because of their failure to seperate it from the speed factor. The concept proposed by Cozens (the difference between predicted and actual times for an endurance run) is another attempt to solve this same problem and seems worthy of investigation.

When running tests are used, one must also consider the type of group being tested. It is apparent that the mean time on an endurance run for a track group should not be directly compared with that for another sports group as a measure of endurance. The past training and individual abilities are different for two such groups. These factors, as well as endurance, would be compared by such a technique. Also, an additional and important factor to be considered is the willingness of the runners to put forth an all-out effort. Henry (9) has shown that psychological factors are significantly correlated

with performance in a 330-yard run.

Improvement in time on an endurance run after an extended conditioning period is another device for estimating improved condition. However, one must consider that a runner's time reflects his running ability and willingness to run in addition to his endurance. Throughout the conditioning period, a track squad should certainly improve in running ability (practice effect) as well as in endurance. A second athletic squad, other than track, despite large amounts of running in connection with its conditioning program, would not be expected to improve as much in running ability because no attempt is made to develop running skill. Thus, at the time of the retest with such a squad, the running ability and willingness to "put out" would be reasonably comparable to that at the first testing. Therefore, any improvement would appear to have been largely caused by increased endurance.

METHOD

Two groups of athletes were used in the study. The first was the University of California freshman basketball squad (1946-47) and the second was a group of men who were candidates for the University of California track team (1947). Both the basketball and track groups were tested in the fall during the early part of their training. The basketball group was tested again late in the season at a time when each player was considered by the coach to be in fine playing condition. The track group was retested late in April at which time each man was in top competing form.

The basketball squad had approximately five weeks of preseason practice prior to starting a schedule of 27 games. In all, this squad participated over a season of 4½ months in length, from November into early March. Twenty men completed all the tests, sixteen remaining on the squad throughout the season. The four remaining players dropped out of the squad for various reasons. However, they continued active basketball participation elsewhere and were retested as part of the experimental group on the basis of an expected gain in condition comparable to that of the squad members. Several other men who took the initial tests were necessarily dropped from the experimental group. Three of these left the squad and did not continue any sort of training, though they were retested at the same time as the others for experimental purposes. The others in this group either dropped from the squad and could not be reached or incurred injuries late in the season and were not retested.

The track group was comprised mainly of sprinters, hurdlers, and middle-distance men. The men started their training in a fall

track program and then continued into the more intense work of the regular spring track season. The group had daily workouts much of the fall and during most of the spring, and at the climax of the season all the men in the group had varsity or junior varsity standing and were actually competing. Of the twenty men initially tested, only twelve continued training and were retested to constitute the experimental track group. The remainder dropped from training, although four were secured for retesting.

The performance measures used were the 75-, 150-, and 300-yard times and the score on the Taylor Pack Test (14). The men ran in pairs to provide competitive spirit and all were timed by the writer who operated two 1/5-second watches. An effort was made to have two watches on each runner, and except for a few cases, an experienced timer, also using two watches, worked with the writer. The two sprints were run the same day, each man running 75 yards first, then resting 15 minutes before running 150 yards. The 300-yard run was done on a subsequent day. In the fall tests, conditions were such that in many cases a lapse of from one to two weeks occurred between tests on the sprints and on the 300. This period between tests was reduced to about one week on the average in the spring tests. It must be conceded that a training gain may have accrued to some during the intervening period between tests in the fall. However, our main interest is the sprinting ability of each subject at the time he ran the endurance race (300). Since very little change in sprinting ability was to be expected over such a short period of time, especially with the basketball men, the established times would certainly seem acceptable. The time lapse in the spring tests seems of even less importance because the subjects were probably maintaining a level of condition through the last few weeks of the season.

An effort was made to motivate each subject on each run. The runs by the track men were in a large measure considered to be regular time-trials, a regular part of their training. The track coaches were always present and it was generally known that they were cognizant of each man's race and the time he made. The men warmed up as for any regular race, and were started by one of the coaches. The writer, also head coach of the freshman basketball squad, used as much persuasion and brought as much pressure to bear as seemed advisable to motivate the basketball men. They also warmed up before each race and were started by one of the track coaches. The track men ran in spiked track shoes while the basketball men ran in regulation basketball shoes. All men used wooden starting blocks.

Most of the basketball men had little or no knowledge of how a race of 300 yards should be run. In order to provide uniformity

the following standardized instructions were given to all: "Get a powerful start and run the straightaway (110 yards) using about nine-tenths effort; run the turn (110 yards) at from three-fourths to seven-eighths effort, and finish with a full effort." This approximates the analysis by Bresnahan and Tuttle (1) of how untrained men might best run a race of this length, and is also comparable to the technique used by Cozens. In the main, the men felt they had run about as good a race as they were capable of running.

The Taylor Pack Test was given to both groups in the fall and the basketball group was retested at the climax of the season. It was considered advisable not to retest the track group since the resultant stiffness and soreness probably would have upset the necessary routine of their midseason conditioning. In the Taylor test, the subject mounts and dismounts an 18-inch stool at the rate of 40 steps a minute, while aided by a hand-hold on a crossbar 6 feet high, and directly in front. The subject wears a pack sack and starts the exercise with one 10-pound weight inserted in the sack. Ten-pound weights are added each two minutes thereafter as long as the subject can continue. The subject is requested to continue the exercise as long as possible, "that is, until fatigue limits the performance." The score is the time from the start to exhaustion, with an arbitrary correction for height, which was worked out by Taylor on the basis of a correlation between height and raw scores. The necessity for strong motivation was recognized and each subject was continually urged to keep at it and prodded repeatedly to produce his best effort.

It was necessary to establish fall scores (early in season) and spring scores (peak condition) on the various measures of endurance for each man and then to evaluate the change taking place over the conditioning period. Other than the straight times on each run and the pack test scores, a number of additional measures were determined.

From the times on the three runs the following indices were established for each man: 300/75, 300/150, and 300-4(75), the latter being the "drop-off."

Using Cozens' concept, the predicted time for 300 yards was established for each man. This predicted time is available from published tables (13) which are based on Cozens' multiple regression equation and which use the man's 75- and 150-yard times. The difference between each man's predicted time and his actual time for 300 yards was also calculated.

In addition, two regression equations to predict 300-yard time from only the 75-yard time were determined. The first equation was

calculated from the data used by Cozens in establishing the original multiple regression equation (above). The second equation was determined from the data on the basketball squad used in this study. Both fall and spring data were used; that is, an average mean, standard deviation, and correlation coefficient (r) were calculated. From these equations, additional predicted times and differences (predicted time minus actual time) were obtained for the experimental groups.

TABLE I

MEAN SCORES BEFORE AND AFTER TRAINING AND SIGNIFICANCE OF CHANGE
Basketball Squad (n = 20)

Test	*Mean Time in Seconds* Fall	Spring	C.R.
300-yard time	40.16	38.89	4.57
Drop-off (300-4x75)	3.08	2.09	2.91
Ratio (300/75)	4.33	4.23	2.78
Ratio (300/150)	2.18	2.13	2.23
Pack Test	504.6	533.4	1.98
150-yard time	18.44	18.22	1.78
75-yard time	9.27	9.20	1.68

TABLE II

MEAN SCORES BEFORE AND AFTER TRAINING AND SIGNIFICANCE OF CHANGE
Track Squad (n = 12)

Test	*Mean Time in Seconds* Fall	Spring	C.R.
150-yard time	16.80	16.08	5.37
300-yard time	35.58	34.26	4.99
75-yard time	8.63	8.42	3.93
Ratio (300/75)	4.13	4.07	2.03
Drop-off (300-4x75)	1.11	0.63	1.98
Ratio (300/150)	2.12	2.13	(—).79

TABLE III

SIGNIFICANCE OF CHANGES IN PREDICTED TIMES PRODUCED BY TRAINING

Predicted times and differences between predicted and actual times based on:
(a) 75- and 150-yard regression equation of Cozens,
(b) 75-yard regression equation using Cozens' data,
(c) 75-yard regression equation using basketball data.

	Test	*Basketball Group C.R. (n = 20)*	*Track Group C.R. (n = 12)*
(a)	Predicted Time (P.T.)	2.35	5.22
	Difference (P.T.—A.T.)	2.08	(—).73
(b)	Predicted Time (P.T.)	1.68	1.23
	Difference (P.T.—A.T.)	2.47	1.22
(c)	Predicted Time (P.T.)	1.57	—
	Difference (P.T.—A.T.	3.88	—

With each measure or index of endurance, it was first necessary

to obtain the *difference* between the fall score and spring score for each man. Then *mean differences* were obtained for each measure, which is the same as the difference between the mean of the fall scores and the mean of the spring scores. Critical ratios (C.R.) were calculated according to the method of small sample statistics.[2]

EXPERIMENTAL RESULTS AND DISCUSSION

It is readily apparent from the data on the basketball group (Table I) that the time on the 300-yard run showed the most significant change as the athletic condition of the basketball players improved during the training period. It is of interest that the 75- and 150-yard times had the smallest critical ratios, considerably below the .05 level of confidence. The ratios and drop-off indices had significant critical ratios, though they were appreciably lower than that with the 300-yard time.

Following the 300-yard time, the next most significant change was alteration in the differences between predicted time and actual time for 300 yards (calculated from the regression equation predicting 300-yard time from 75-yard time, as shown in Table III). The differences calculated from the regression equation based on both 75- and 150-yard times as a prediction of 300-yard time were of rather low significance. The underlying principle behind this difference between actual and predicted time, as we have seen, lies in a consideration of the correlation between time on an endurance run and sprint times. If it is accepted that this correlation is explained mainly by the presence of a speed factor in both runs (the sprint being mainly speed), then endurance must be among the residual factors which cannot exceed $\sqrt{1-r^2}$ (Coefficient of Alienation). This difference then, seeks to remove the speed factor, as represented by the predicted time, so as to leave the endurance factor in the residuals, as suggested by Henry and Kleeberger (10).

Certainly the high correlation between the sprints and the 300-yard run as shown in Cozens' study, would indicate an abundance of speed in the 300-yard run and a rather small amount of residual endurance. In seeking to investigate this concept further, the regression equation to predict 300-yard time from only the 75-yard time was worked out. This equation was based on a correlation of r=.911 whereas the original multiple regression equation, adding the 150-yard time, had a multiple R=.955. Theoretically, inclusion of the

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[2]Most of the modern textbooks on statistics discuss small sample statistics. (See, for example, Guilford, J. P. *Fundamental Statistics in Psychology and Education*. New York: McGraw-Hill, 1942, p. 130.) Using this method, a difference that is significant at, say, the one percent level of confidence has the same statistical significance regardless of the number of individuals in the sample. A larger C.R. is of course required if the number of individuals is small, but this is taken into account by the method.

150-yard time, which should contain more of the endurance factor than the 75, would increase this correlation and so decrease the amount of residual endurance with which to work. Then with the difference between predicted and actual time, the inclusion of 150-yard data in the predicted time causes an increased amount of the endurance factor to be removed This seems to be borne out by the data on the basketball group as the C.R. rises from 2.08 to 2.47 when only the 75-yard time is used for predicting purposes (Table III). A corresponding increase is seen with the track squad, the C.R. rising from —.733 to +1.22. (The difference, using the original regression equation, showed a decrease on the average over the track season.) Using the regression equation obtained from the basketball data where the correlation between 75- and 300-yard time (r=.370) was much lower than in Cozens' data, the C.R. jumped to 3.88.

Generalizations from the data on the track group must be made with caution. However, analysis of the changes in the various measures helps to clarify the worth of these concepts as group measures of endurance. This group improved significantly on all the runs, with most improvement being shown on the 150-yard run. This sprint improvement is also reflected in the high C.R. for the predicted time, which is calculated from these sprint times. This speed improvement is in contrast to that of the basketball group which showed only a slight improvement on the sprints, though both groups showed improvements in the 300-yard run. It was indicated earlier that time in a run is influenced by a number of factors, which might be summed up as running ability plus endurance. With the majority of these runners specializing in sprint work, though they all had occasional practice in runs up to 352 yards (1/5 mile), a large "practice effect" would be expected to accrue, especially in the sprints. It follows also, that improved running ability in addition to increased endurance is reflected in the better time on the 300-yard run. However, with the basketball group, since little improvement in running ability is indicated, most of the improvement in 300-yard time is probably due to increased endurance.

In view of the data, the use of such endurance indices or ratios as measures of endurance is of questionable value. Attempts to eliminate the speed factor from time on the 300-yard run only result in lower critical ratios than are obtained using the 300-yard run alone. Indeed, it appears that the apparent strength of these critical ratios is dependent on the improved 300-yard time, and where improved sprint time is also a factor, as with the track group, these indices are appreciably less significant. In fact, the track group shows less endurance on the retest than on the first test, as measured by indices using the 150-yard times in combination with 300-yard times.

The trends indicated above have bearing on the theoretical devices attempting to separate speed and endurance with runs such as these. The difference between actual and predicted time seems best in theory and has the most significant change during training.

It should also be pointed out that the raw scores on a run such as 300 yards may have little value in estimating present endurance. The track squad has consistently better raw scores than the basketball group, but it must be considered that the raw scores evidently reflect running ability and willingness as well as endurance. However, the data do indicate that improvements in the various endurance measures, 300-yard times in particular, are measures of changing athletic condition.

The improvement in condition of the basketball squad, as measured by the maximal pack test, is of low significance, being just below the .05 level (Table I). This C.R., of course, is considerably lower than that obtained with the 300-yard times.

The use of the pack test in this study has been enlightening in regard to its worth as a performance measure. Correlations between the pack test and 300-yard times were —.37 for the basketball group and —.49 for the track group. No reliability figures are available on the test. However, it appears that this may be comparable with our other performance measures. The correlation between test and retest (the training period intervening) is .79. Comparable coefficients of .68 and .83 respectively for the ordinarily reliable 300-yard and 75-yard runs were obtained. Though these figures are not presented as reliability coefficients, they serve to indicate that the reliability of the pack test probably does not restrict its validity.

Regarding its validity, Taylor has presented a study of pack test scores and athletic performance test scores on a group of 35 men. He concludes that "no one obtained a good athletic score unless he achieved a high pack-test score" (14). No correlation coefficient was presented. However, from the scattergram it was computed as r=.30. Also, on inspection it is clear that the two men ranking second and third on the athletic test rank no better than eleventh and twelfth on the pack test, and of the 17 men scoring above the median on the athletic test only 10 of them were above the median on the pack test. This observation is not in agreement with Taylor's statement. The test battery used is of the type developed in the armed services as a measure of physical fitness, and probably could not be defended as a measure of general athletic ability. In consideration of the obtained correlation, and the nature of the athletic test used, the implication that exercise tolerance (as measured by the pack test) is fundamental to athletic ability seems very questionable.

It is conceivable that though the pack test did not indicate any appreciable gain in the basketball players' condition, it may be a valid test of some form of exercise tolerance. However, such validity must be dependent on the all-out performance of the subjects—i.e., *exhaustion*. It was felt by the writer that the subjects in this experiment did very well on the test; the basketball squad on retest had a mean score equal to that obtained by Taylor with ten men who ranked in the upper ten percent of the college student body in athletic tests; still, it was very apparent that few of the basketball men were in a state of exhaustion at the end. The athletes in the present study were surely well acquainted with the competitive type of all-out performance. However, such knowledge conceivably could result in a limited performance on the part of some subjects when confronted with a severe exercise having little to do with actual competitive effort. This argument could apply to the use of an endurance run as well, though the writer feels that the basketball group appeared to show considerably less aversion to the runs than to the pack test. In conclusion, it appears that the maximal pack test to a high degree is affected by the willingness of the subjects to give an all-out performance, yet under strong motivation or compulsion it may give valid measures of some form of exercise tolerance.

Many of the subjects of this study were subjected to physiological measurement by F. M. Henry and W. E. Berg.[3] They were tested in early training and again during the latter part of the competitive season at times comparable with the performance tests. Complete records were obtained on only 16 basketball players. However, it is significant that oxygen-debt measures were appreciably better than the best performance measures as indicators of improved condition. Critical ratios were as follows:

	Oxygen Debt	*300-Yard Run*	*Pack Test*
C.R.	4.88	3.34	2.55

While a test such as 300-yard time has a reliability coefficient of over .90, Berg reports a reliability of only .62 for the oxygen-debt measures. The contention that the oxygen-debt measure is more valid is thus supported, since its advantage would be even greater, relatively, when corrected for attenuation.

SUMMARY AND CONCLUSIONS

A freshman basketball squad of 20 players and a second group of 12 varsity runners made up the two experimental groups studied. The athletes were tested early in their conditioning period and again

[3] F. M. Henry, personal communication.

late in their competitive season. The test included times on the 75-, 150-, and 300-yard runs and scores on a maximal pack test.

On the basis of findings with the basketball squad, it may be concluded:

1. That the time on 300 yards showed the most significant change over the season and appears to be the most effective performance measure of improved condition.

2. That various endurance indices based on work decrement and adjustment for speed were all of less value than the 300-yard time in detecting the change in condition.

3. That the change in condition as detected by the maximal pack test was of low significance, being just below the .05 level.

The track group was improved significantly in all three runs, the largest change being in 150-yard time. The so-called "endurance indices" were of little value in detecting condition change in this group.

It should be emphasized that with performance measures such as the 300-yard run, the scores are probably affected by factors other than endurance. These would include judgment of pace and running skill; also of importance is the willingness to go "all-out." Thus, time on such runs would not be of much value in estimating the present condition of a group. However, the change over a conditioning period does seem to offer a practical measure of improved condition. Where an athletic squad receives no particular track practice it should be expected that such factors would be cancelled out in the test-retest comparisons, and the improvement would be largely in endurance.

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Research Abstracts

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By Granville B. Johnson

ANATOMY

Washburn, Sherwood L. Sex differences in the pubic bone. *Am. J. Phsy. Anthrop.*, N.S., 6:2 (June, 1948).

The length of the pubis and ischium was measured on 300 human skeletons of known race and sex in the collection of the Hamann Museum at Western Reserve University. The pubis is shorter in Negroes than in Whites. The pubis is relatively longer in females than males. The ischium-pubis index averages 15% higher in females than in males, and the sex of over 90% of skeletons can be determined by this proportion. The size of the subpubic angle and many other characters which distinguish the female pelvis are dependent on the pubic bone. The sex difference in the sciatic notch belongs to an entirely different anatomical system. The combination of an observation on the notch and the ischium-pubis index will determine the sex of almost any skeleton.

Gardner, Ernest. The innervation of the knee joint. *Anat. Rec.*, 101: 1 (May, 1948).

The gross and miscroscopic distribution of nerves to the human knee joint was studied in dissections of adult joints and in serial sections of fetal joints. The articular nerves are derived from the femoral, obturator, tibial, common peroneal, and recurrent peroneal nerves. Cases recorded in the literature indicate that on rare occasions the accessory obturator nerve also supplies the knee joint. There is marked individual variation in the gross distribution of articular nerves. Within the joint, however, the area of supply of a particular nerve is rather constant. There is considerable overlap of various nerves. Many of the nerve fibers undoubtedly end in association with the blood vessels supplying the capsule and epiphyses. Other fibers form small but numerous bundles in the connective tissue of the posterior part of the capsule. If the knee joint of man is similar to that of other animals studied previously, proprioceptive endings are numerous in this region.

Gray, John E. Congenital absence of the tibia. *Anat. Rec.*, 101: 3 (July, 1948).

A case of congenital absence of the tibia, talus, navicular, cuneiforms, 2 metatarsals, and the 3 medial toes is described. The tibialis posterior, extensor hallucis longus, extensor digitorum brevis, abductor hallucis, flexor hallucis brevis, 1st and 2nd lumbricals, transverse head of adductor hallucis and the medial interosseous muscles were also absent. A large supernumerary muscle "peroneo-tarsus" was present. Other muscles had abnormal insertions. The muscular abnormalities were not connected with the segmental nerve supply. It is suggested that the defect extended to include the corium of the medial side of the sole. The great saphenous vein, the saphenous nerve and muscular branches of the medial plantar nerve were also absent. The literature is reviewed. A critical survey of possible causes of the defect is made. It has not been possible to assign a cause for the abnormality. A few of the transmissions from father to son are cited in the literature. Two cases of occurrence of the defect in siblings are also cited.

BIOCHEMISTRY

Mancini, Roberto E. Histochemical study of glycogen in tissues. *Anat. Rec.*, 101: 2 (June, 1948).

A histochemical study of glycogen was carried out in different tissues, comparing chemical fixatives with frozen-dried sections and smears. The iodine-reaction was carried out in a non-polar solvent so as to avoid the use of water and to permit the study of frozen-dried sections with a minimum of artifacts, avoiding displacement, extraction, and hydrolysis of glycogen. With this technique glycogen appears in greater amounts and is more regularly distributed than with chemical fixation. Glycogen was found to be homogeneously distributed in the cytoplasm of cells of cartilage, liver, vaginal and skin epithelium, endometrium, fatty tissue, placenta, kidney, and in the glycogenic organ of the chicken. A granular distribution was found in muscle and leucocytes. During skin regeneration an increased amount of glycogen and a wider distribution is observed. These results are compared with those obtained with chemical fixation and the true distribution of glycogen in the cell is discussed.

HEALTH EDUCATION

Maxwell, Cyrus H. Administration of school health service. *School Life*, 30:8 (May, 1948).

A short review of the literature was made to attempt to reveal trends in the administration of school health services from 1920 to 1947. The administration and financing of the school health program is still overwhelmingly under educational authority, especially on the local level, and shows no particular trend toward a change in administration. This study is informative relative to the responsibilities for legal administration, by state and local units, employment of public health nurses, and financing of the school health program.

NUTRITION

Glickman, Nathaniel, Harold H. Mitchell, Edward H. Lambert, and Robert W. Keeton. The total specific dynamic action of high-protein and high-carbohydrate diets on human subjects. *J. Nutrition*, 36:1 (July, 1948).

From the results of experiments on 12 young men, using 2 types of meals containing about 1,000 cal., practically the same content of fat calories, and 7 and 37% of protein calories, the following information was obtained:

1. The rate of accumulation of extra calories above the basal level follows a sigmoid curve, the accelerating phase terminating at about 1.5 hours after the high-carbohydrate meals, and 2 to 2.5 hours after the high-protein meals. Thereafter, the rate of accumulation of extra calories is well described by the equation expressing the law of diminishing returns.

2. From equations of the latter type fitted to the experimental data, the total S.D.A. was calculated and found to average 17% of the calories of the high-protein meals, and 10% of the calories of the high-carbohydrate meals.

3. Compared to even the lightest types of muscular activity, the S.D.A. of food seems to be a small item in the energy economy of man.

Sognnaes, Reidar F. Experimental rat caries. I. Production of rat caries in the presence of all known nutritional essentials and in the absence of coarse food particles and the impact of mastication. *J. Nutrition*, 36:1 (July, 1948).

Two experiments have been carried out to test whether masticatory injury to the enamel is essential for the production of rat caries, as has been claimed in recent years.

Evidence has been presented that a purified ration, adequate in known nutrients, is conducive to rat caries independently of the presence of coarse food particles and the impact of mastication. Demonstration of a caries-conducive mechanism operating before tooth eruption, the absence of enamel fractures and attrition, and the persistence of weakly supported overhanging enamel walls surrounding undermining caries, all tend to indicate that the described lesions are not caused by mechanical injury to the teeth. No difference can be found between the histopathology of the rat caries here presented and presently established findings in man.

Murlin, John R., Thaddeus A. Szymanski, and Elizabeth C. Nasset. Creatinine nitrogen percentage as a check on the biological values of proteins. *J. Nutrition*, 36:1 (July, 1948).

Creatinine excretion in human subjects is quite constant (mean deviation from the mean is less than 5%) despite ingestion of various proteins in the diet. If the creatinine nitrogen as a percentage of the total urinary nitrogen is plotted against the biological value of the dietary proteins, determined by the nitrogen balance method, a straight line is obtained. This relationship holds over a range of biological values from 42 for wheat gluten to 100 for whole fresh egg proteins. The data from 14 nitrogen balance experiments on man are included.

Radomski, Jack L., Geoffrey Woodard, and Arnold J. Lehman. The toxicity of flours treated with various "improving" agents. *J. Nutrition*, 36:1 (July, 1948).

Bread made from flour which has been treated with agene, a commonly used "improving" agent whose active ingredient is NCl_3, produces running fits in dogs. This property is not possessed by any other important bleaching agent. Apparently a combination of NCl_3 with the protein of flour is the basis of the toxicity. Gluten can be heavily treated with NCl_3 to yield a product which produces running fits in dogs after a single administration, as contrasted to normally treated flour which requires at least a week of feeding large quantities to produce fits. The ED 50 (effective dose 50%) of gluten "saturation-treated" with NCl_3 is approximately 3.5 gm per kilogram. The reaction product of NCl_3 and either tyrosine, tryptophane, cystine, cysteine, or methionine is not responsible for this phenomenon. The production of central nervous system disorders by agene-treated gluten is not a phenomenon peculiar to the dog, but rather a toxic reaction common to several species, notably the rabbit and cat. However, rats, guinea pigs, and monkeys appear upon gross observation to be unaffected. The rabbit may offer numerous advantages as an assay animal over the dog.

Hawley, Estelle E., John R. Murlin, Edmund S. Nasset, and Thaddeus A. Szymanski. Biological value of six fat-extracted proteins. *J. Nutrition*, 36:1 (July, 1948).

This is part of a cooperative endeavor, proposed by the Bureau of Biological Research of Rutgers University, to resolve discrepancies regarding protein utilization of different animal species. The present paper deals with the determination of biological values of 6 proteins using human subjects (6 females, 8 males). The "non-protein" portion of the diet supplied adequate calories (35% from fat), minerals, and vitamins and contained about 0.2 gm N per day. The protein-free periods were preceded by a period of low intake of whole fresh egg. The test proteins furnished 2.44 to 5.33 gm N per day, depending upon their anticipated biological value. The biological values obtained were: powdered whole egg, 94; egg albumen, 91; cooked casein, 68 and 69; beef powder, 67; raw casein, 56; peanut, 56; wheat gluten, 42.

Physical Education

Bookwalter, Karl W. A study of the Brouha step test. *The Physical Educator*, 5:3 (May, 1948).

The Brouha Step Test was administered to 1,269 ASTP students at Indiana University in December, 1943, as a part of the regular testing program. As measured, it does not appear that the Brouha Step Test is related to physical fitness as measured by the Army physical education test items, nor to age, height, weight, and 100 yd. pick-aback and 300-yard dash.

Franklin, C. C., and Lehsten, N. G. Indiana physical fitness test for the elementary level (grades 4 to 8). *The Physical Educator*, 5:3 (May, 1948).

Norms for the elementary schools for the Indiana State Physical Fitness Test were set up. These norms were based on over 4,000 cases, boys and girls, and were set up for Classification Index I grouping for both boys and girls. The directions for giving the test are also given as are a sample of the individual test card and an adapted table for computing Classification Index I for ages 9-17 and heights 48-78 inches.

Physiology

Strandskov, Herluf H., and Sara Einhorn. On the relation between age of mother and percentage of stillbirth in the total, the "white," and the "colored" U.S. populations. *Am. J. Phys. Anthrop.*, N.S., 6:2 (June, 1948).

The percentages of stillbirth for 9 different age groups of mothers are calculated. The data include 30,397,158 births (live and stillbirths combined). It is found that the percentage of stillbirth for young mothers (age 10-14) is high (6.70%); this decreases for each successive age group up to age group 25-29 (3.00%), and then rises gradually to a peak of 8.09% at the end of the reproductive span of the human female. The differences between most of the successive age groups are found to be statistically significant. The same trend is found for the "white" and the "colored" populations considered separately but the percentage of stillbirth for each age group of mother within the "colored" population is significantly higher than each of the corresponding ones for the "white." The differences in percentages of stillbirth with respect to age of mother are concluded to be due primarily to differences in function of the endocrine system. The racial difference is considered to be due primarily to environmental factors.

Morrison, Peter R. Oxygen consumption in several mammals under basal conditions. *J. Cell. and Comp. Physiol.*, 31:3 (June, 1948).

Measurements of oxygen consumption in 9 species of small wild mammals, rodents, insectivores, and bats, were carried out under close to basal conditions. Similar measurements were made on white mice and the value obtained (7.6 cal/gm hr. or 17.6 cal/gm ^{73}hr.) compared well with those of other authors on this animal. The results on the wild mammals in each group were compared to each other and to data on related species in the literature. The 3 orders appear to form distinct groups in respect to basal metabolism. The average values in cal/gm ^{73}hr. were: rodents, 17.1; insectivores, 30; and bats, 4.5.

Taylor, Clara M., Orrea F. Pye, and Anne B. Caldwell. The energy expenditure of 9- and 11-year-old boys and girls (1) standing drawing and (2) dressing and undressing. *J. Nutrition*, 36:1 (July, 1948).

Using a respiration chamber the energy expenditure of 7 boys and 12 girls, 9 to 11 years of age, selected from a home for children and from a private school, has been measured while they stood drawing as though at the

blackboard in school and while they were dressing and undressing. Eleven determinations were obtained on the boys, 14 on the girls.

For standing drawing the average expenditure by the boys was 3.19 cal. per kilogram per hour (125% above their average basal metabolism) or 0.83 cal. per centimeter of height per hour (137% above the average basal metabolism). For this activity the girls averaged 2.62 cal. per kilogram per hour (76% above their average basal metabolism) or 0.63 cal. per centimeter of height per hour (80% above the average basal metabolism). For dressing and undressing the average expenditure by the boys was 4.29 cal. per kilogram per hour (202% above their average basal metabolism) or 1.09 cal. per centimeter of height per hour (211% above the average basal metabolism). The girls for this activity averaged 4.04 cal. per kilogram per hour (171% above their average basal metabolism) or 1.00 cal. per centimeter of height per hour (186% above the average basal metabolism).

MISCELLANEOUS

Carter, Gerald C. Are lady professors hard to please? *School and Society*, 68:1749 (July 3, 1948).

One hundred fifty-five instructors and 4,904 students at Purdue University were involved in the study. Instructors were asked to rate students on the following scale: 6, superior; 5, very good; 4, average; 3, poor; 2, very poor; 1, inferior. Critical ratios of differences between the means of the categories established according to sex of students and rater indicated a significant difference between men and women raters. Women were less generous than men in ratings issued for both men and women instructors. Female students received higher ratings than male students from both the male and female instructors.

Franseth, Jane. Measuring the effects of supervision. *School Life*, 30:9 (June, 1948).

This is a tentative report of the evaluation of supervision in several county schools in comparison with non-supervised county schools in Georgia. Standardized tests have been administered and some of the results are indicated in this article. The results indicate that the schools receiving supervision are producing broader understandings and greater achievements.

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Ogden, Jean, and Jess Ogden. *Small Communities in Action*. New York City: Harper & Brothers, 1946. (books)

Deaver, G. G. Exercise and heart disease. *Research Quarterly*, 10:24-34, 1939. (periodicals)

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While *Quarterly* style is preferred a modification of it may be used if the essential information is given.

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